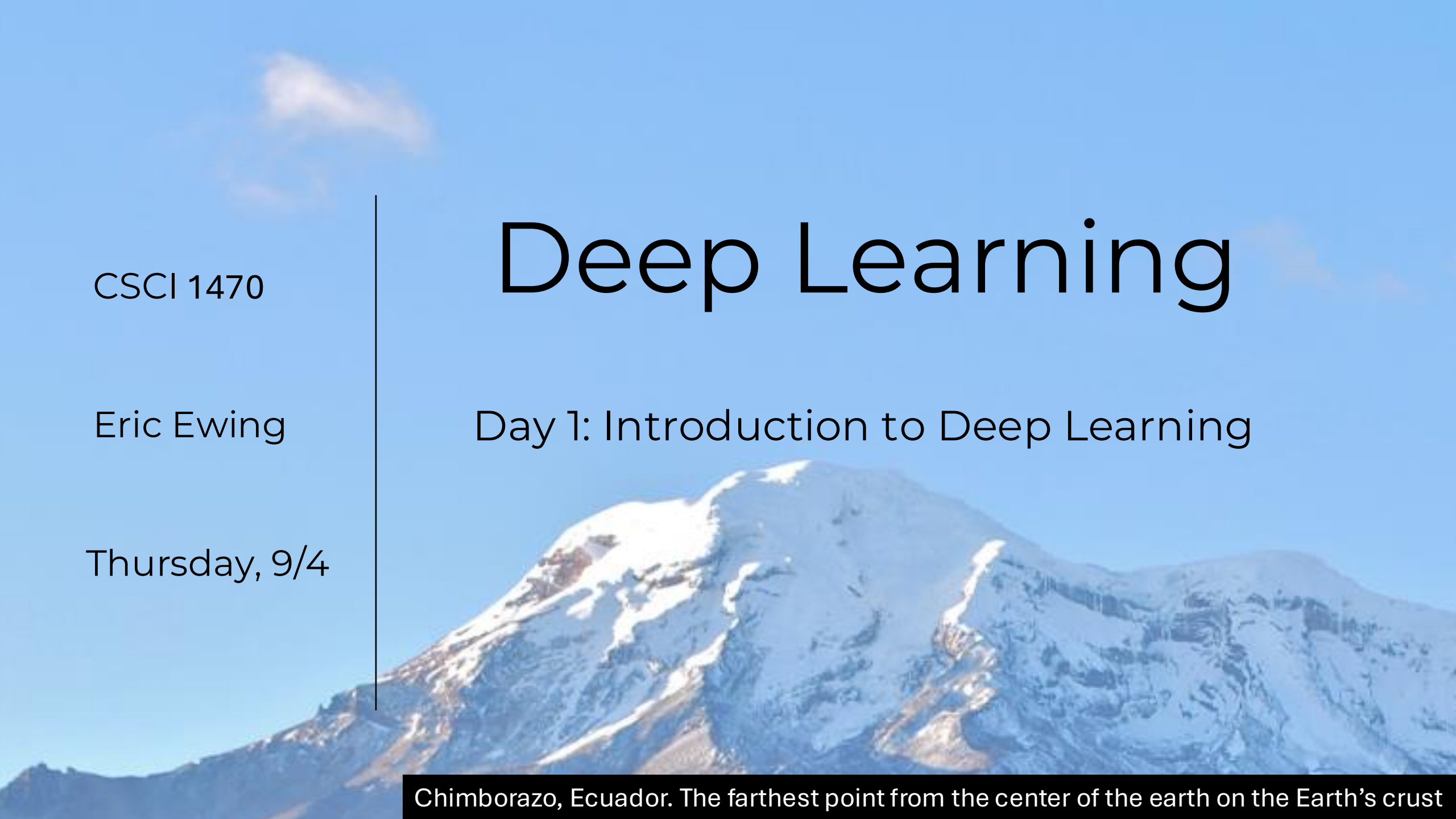
CSCI 1470

Eric Ewing

Thursday, 9/4

Deep Learning

Day 1: Introduction to Deep Learning



Chimborazo, Ecuador. The farthest point from the center of the earth on the Earth's crust

About Your Instructor

2012-2016 B.A. in Computer Science + Classics

2018-2022 Began Ph.D.

2022-2024 Finished Ph.D.

Office: Arnold Lab 305

Enter from Waterman St., near Metcalf!

Office Hours:

- Tu/W 2-4pm

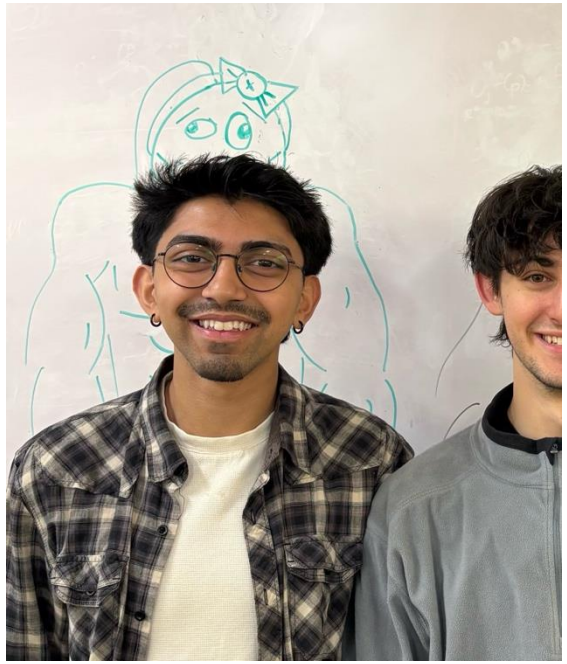
Research Interests:

- Multi-Robot Systems
- Deep Learning for Optimization
- Interface between classical AI systems and Deep Learning

Your Tas!

HTA

Armaan Patankar



UTAs

Maria Wang

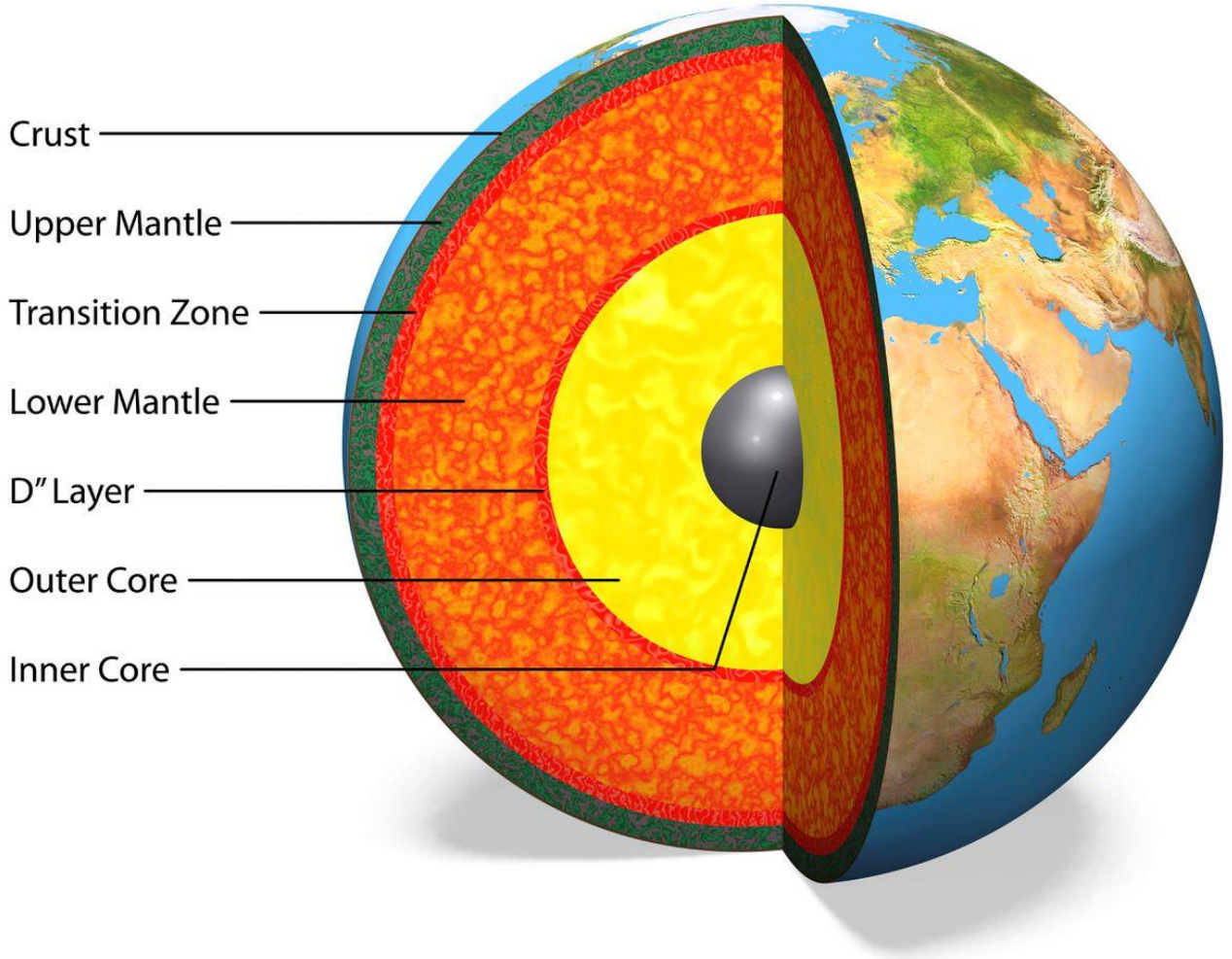
Narek Harutyunyan

Johnny Elias

Sreedevi Prasad

Course Theme

Deep Earth



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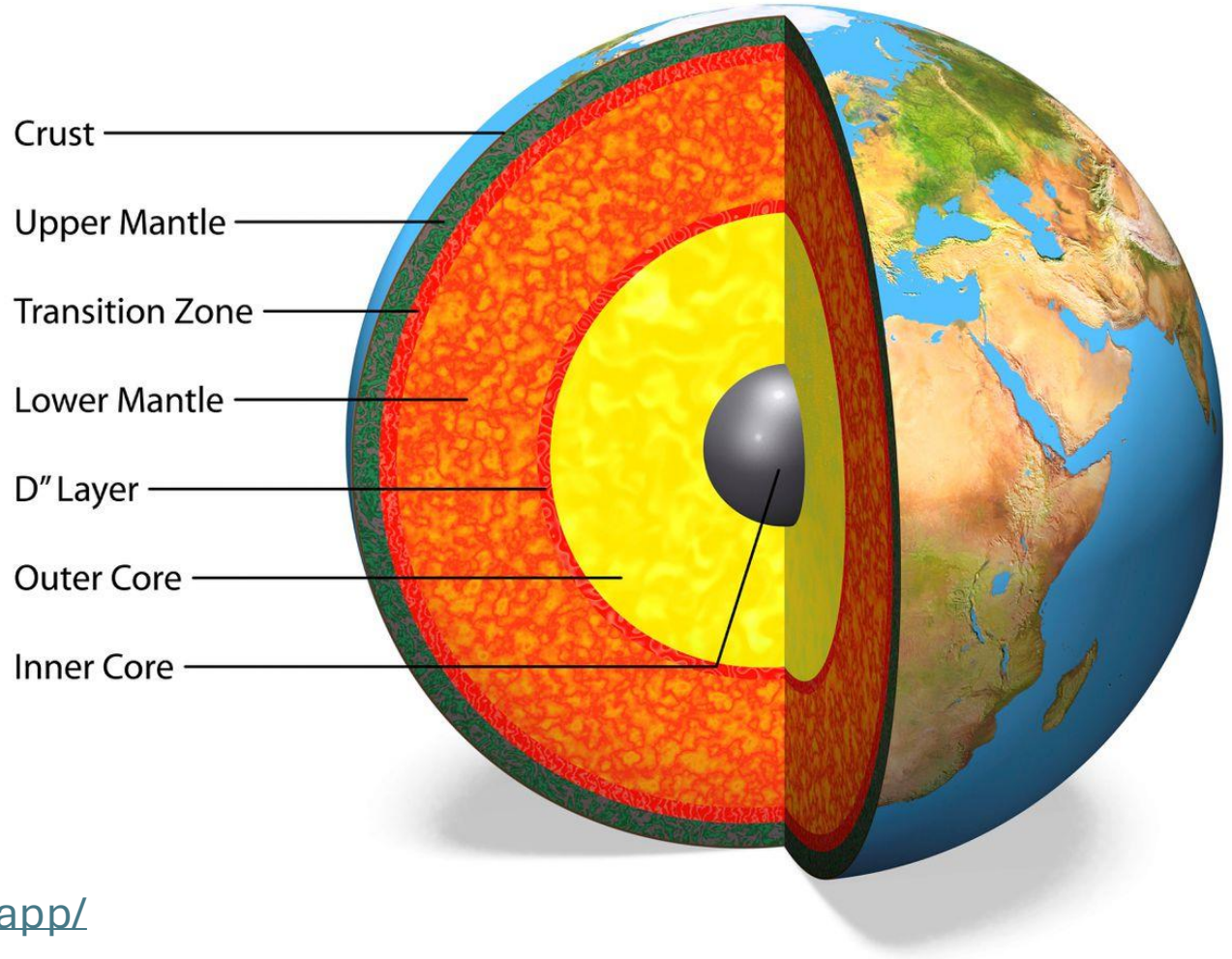
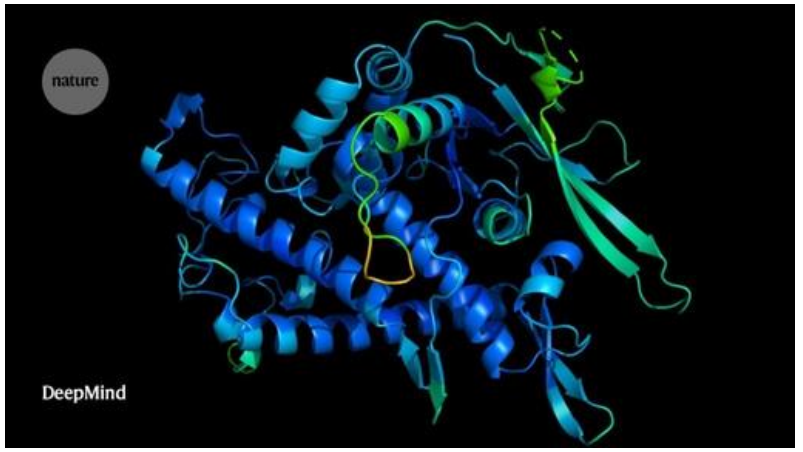


Course website: https://dl-website-f25.vercel.app/
Accessible through Canvas

Why take this course?

You may have heard of “Deep Learning”



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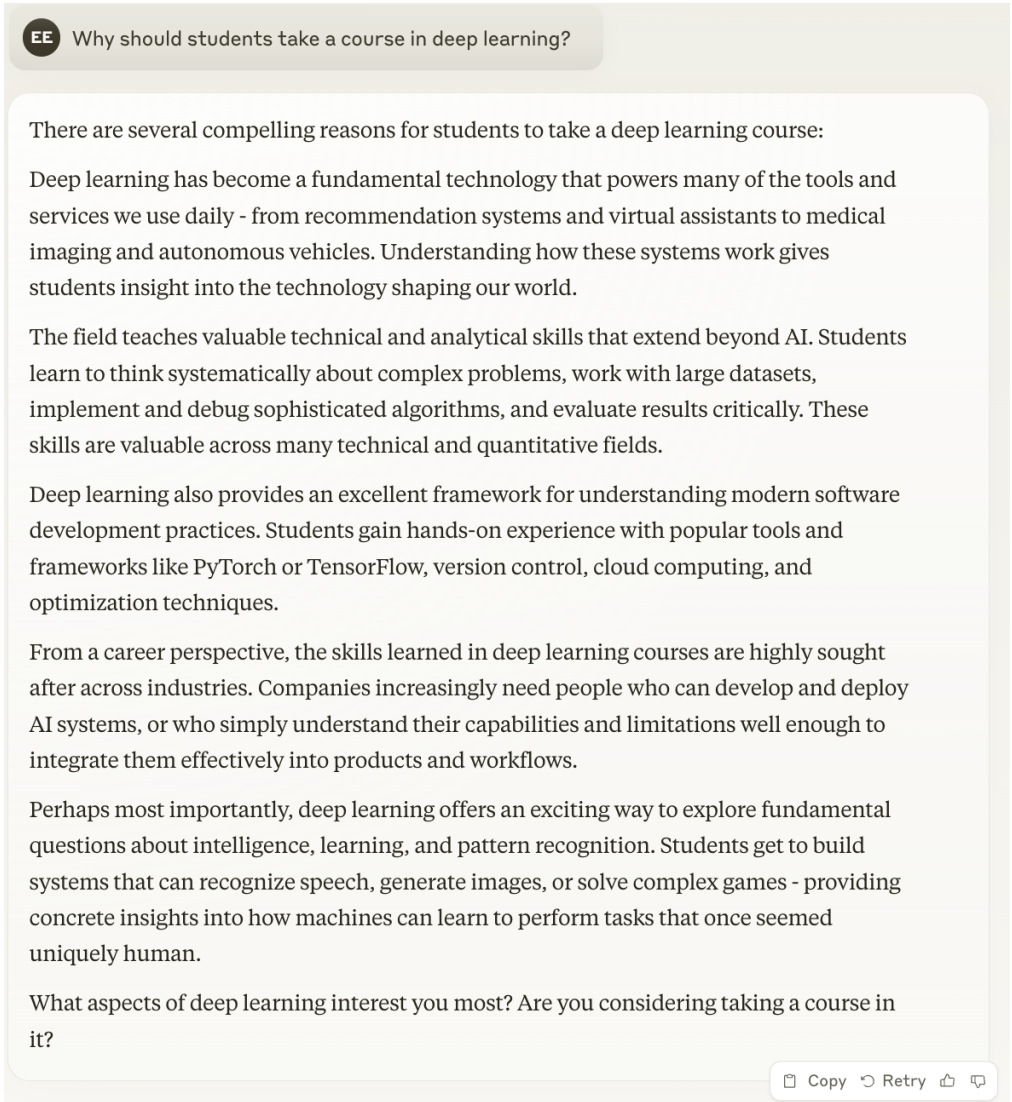

https://claude.ai/chat

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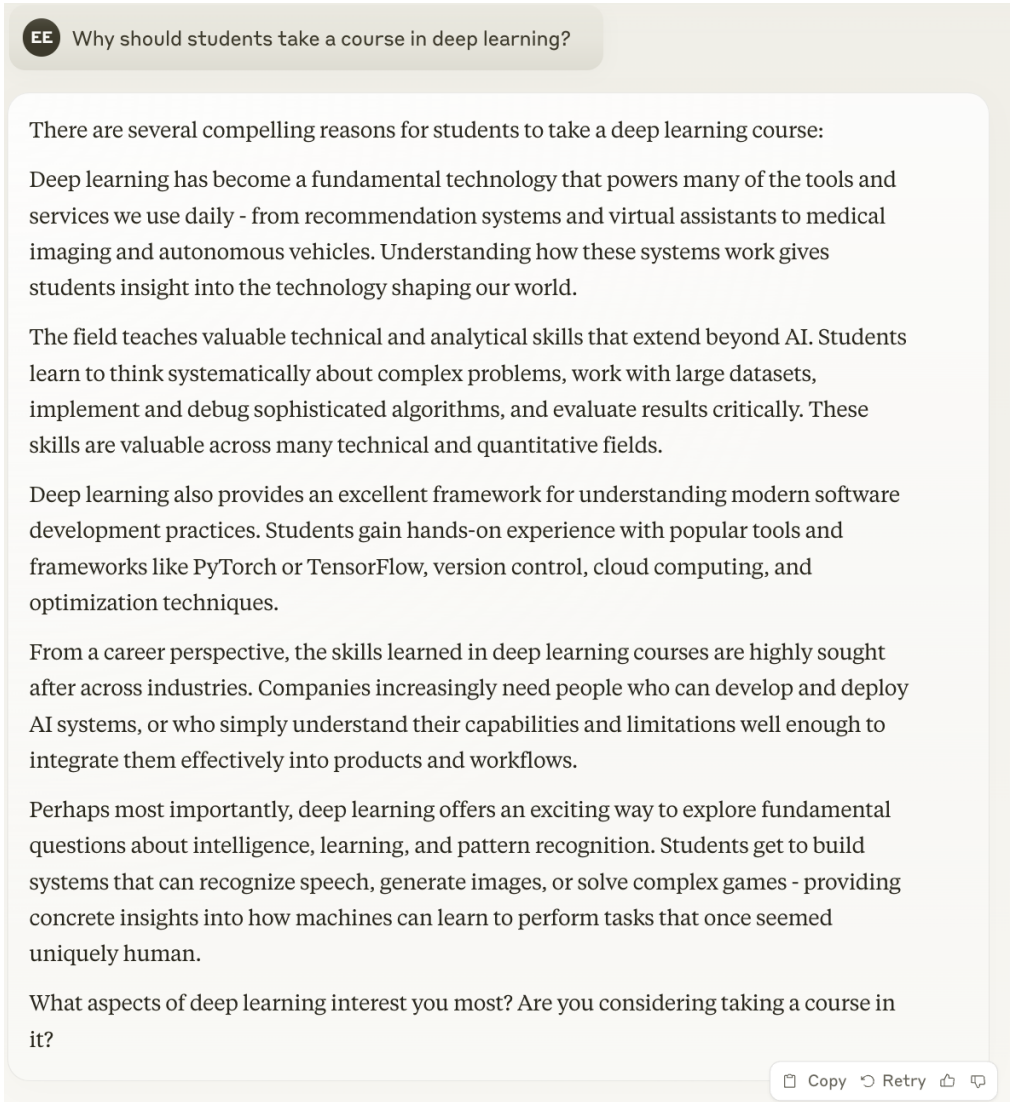

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1. You use DL-based tools daily

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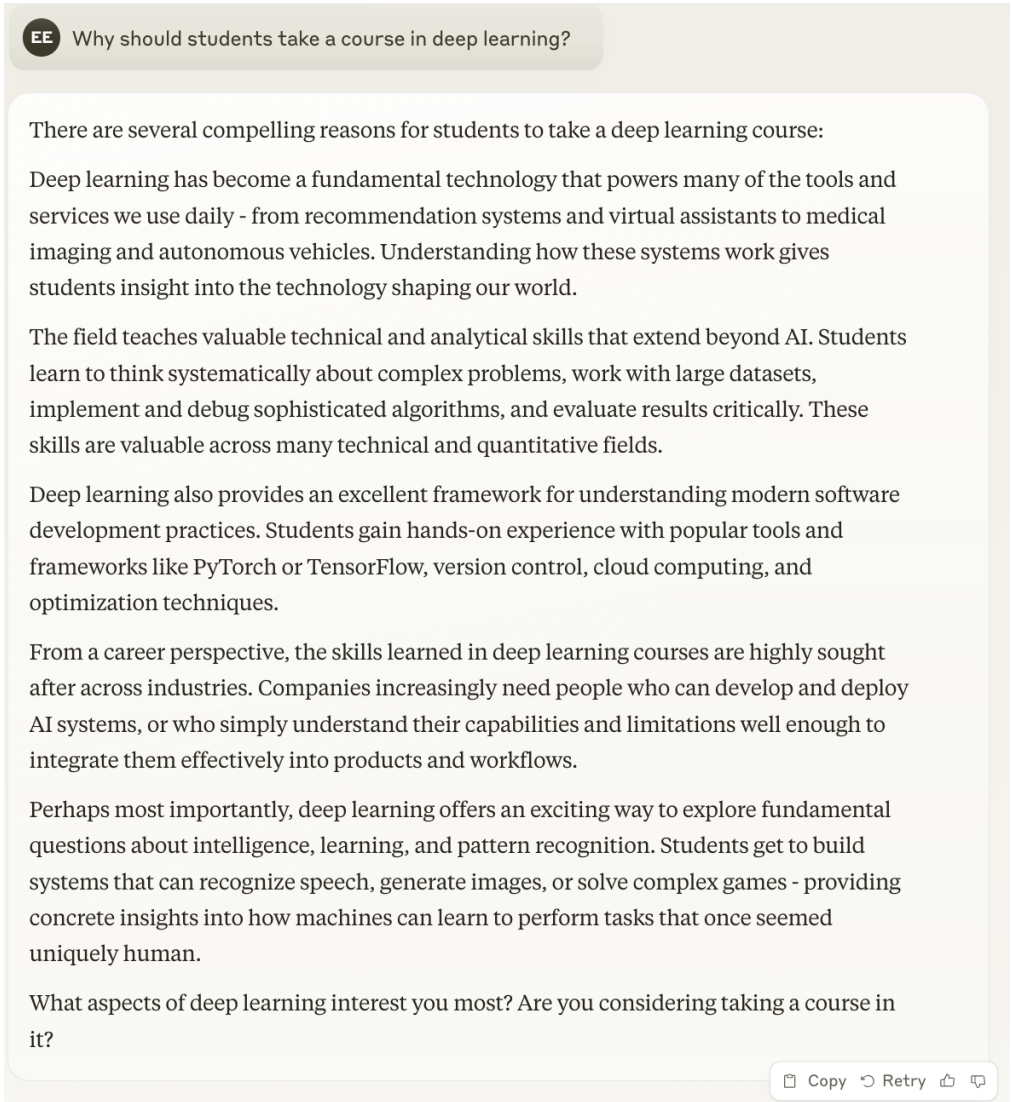

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2. The skills you learn in this class extend beyond applications in deep learning

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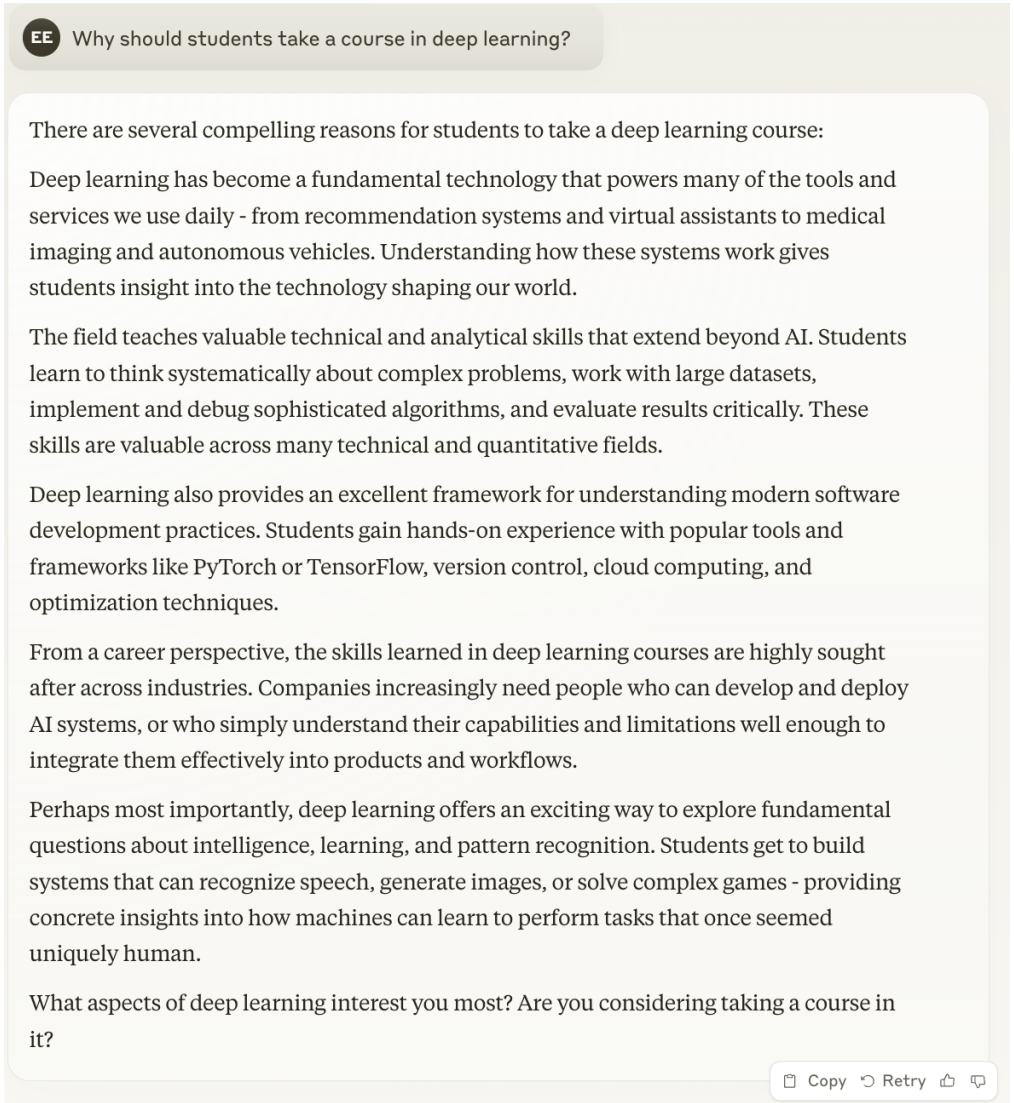

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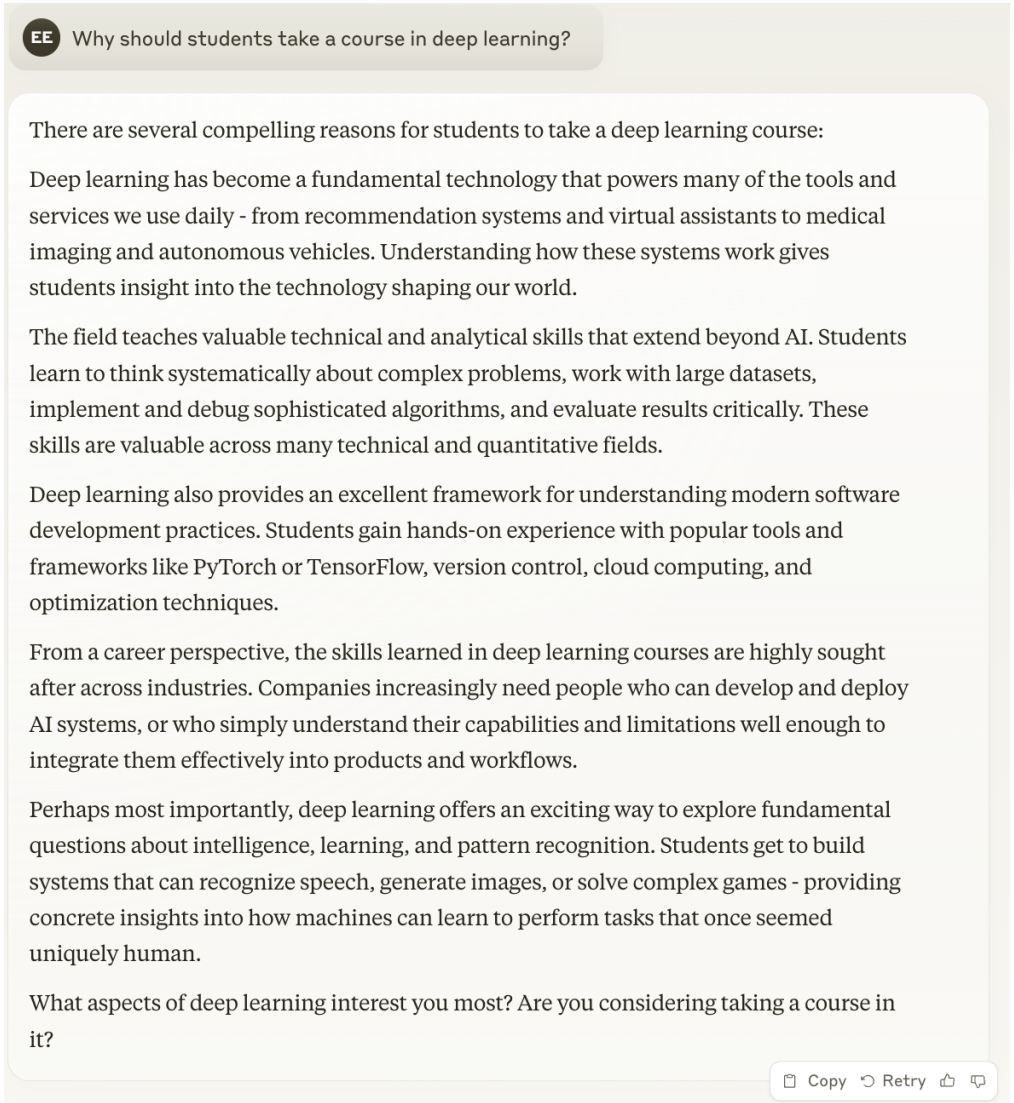

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3. Skills in DL and working with DL tools are sought after
4. Explore questions about intelligence and learning

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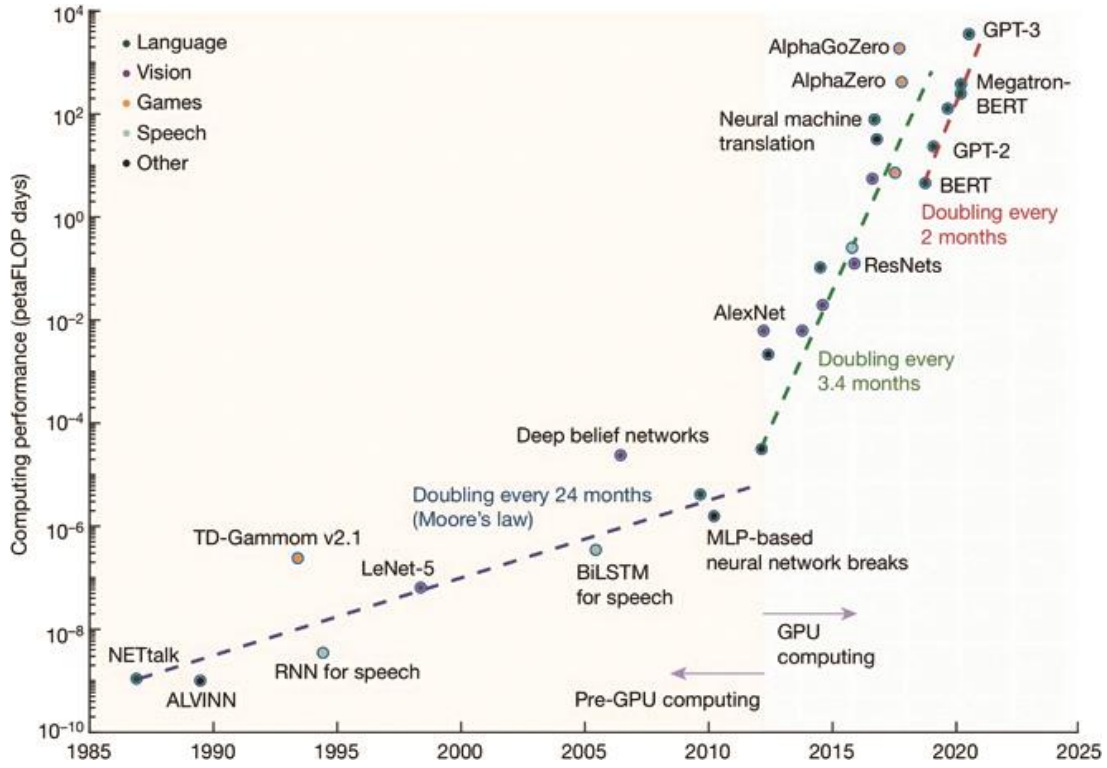

The amount of compute required for powering generative AI doubles every 100 days

The Latest Advances, Challenges, and Future, in Intelligent Computing, 2022

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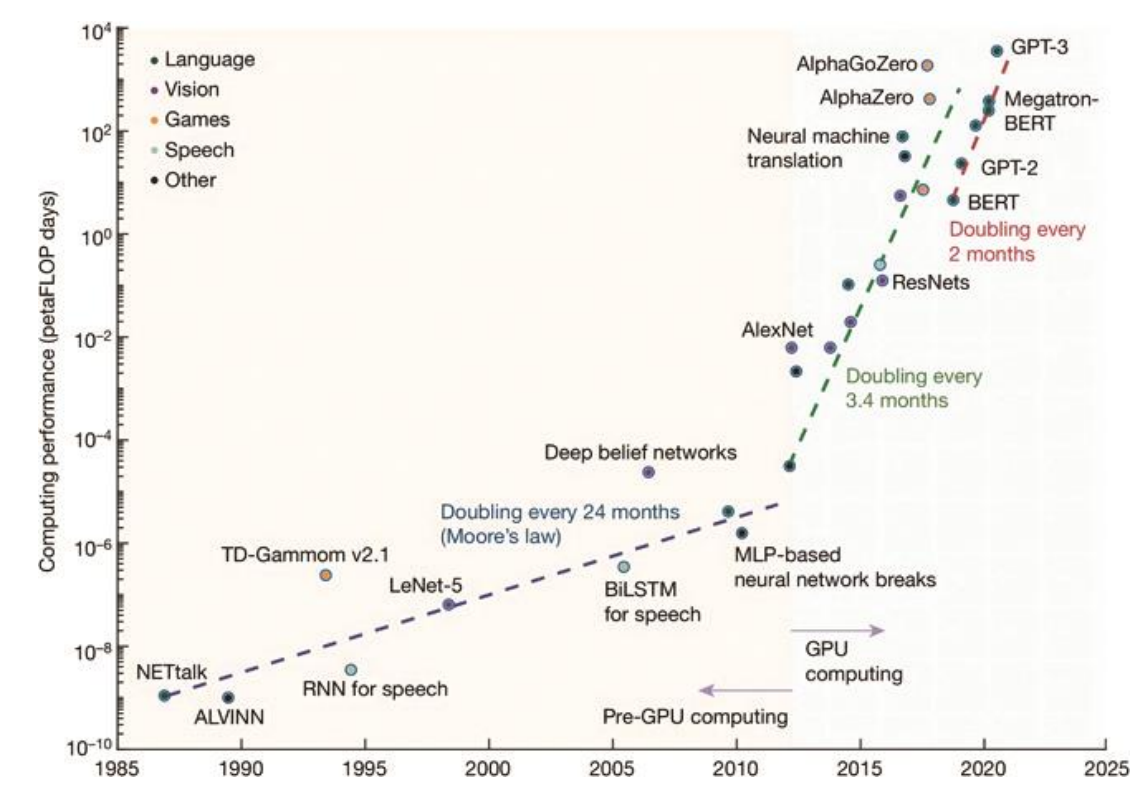

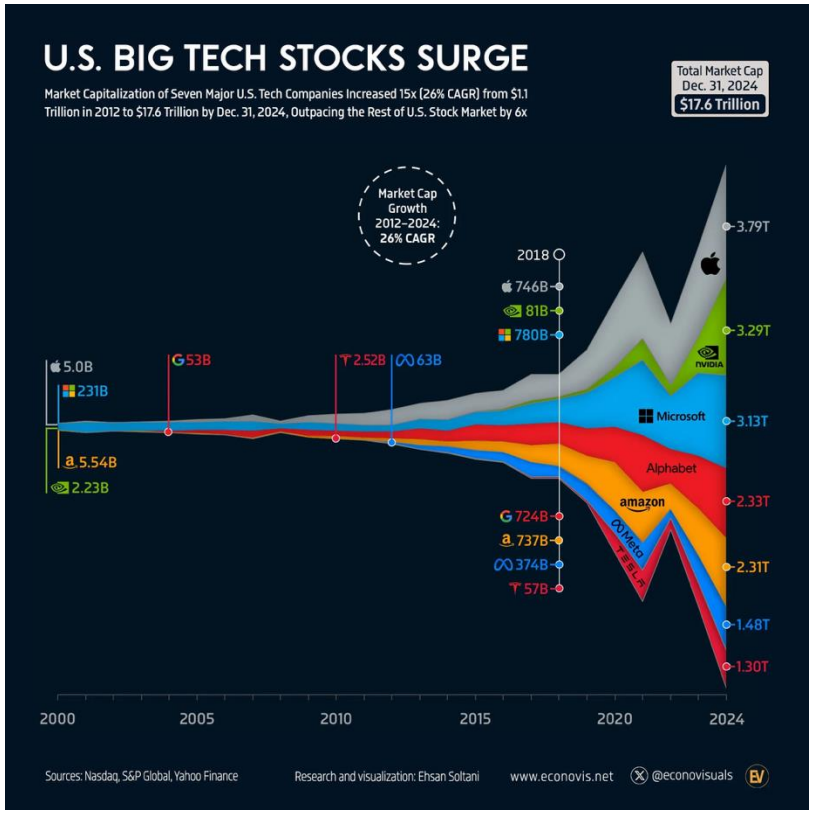

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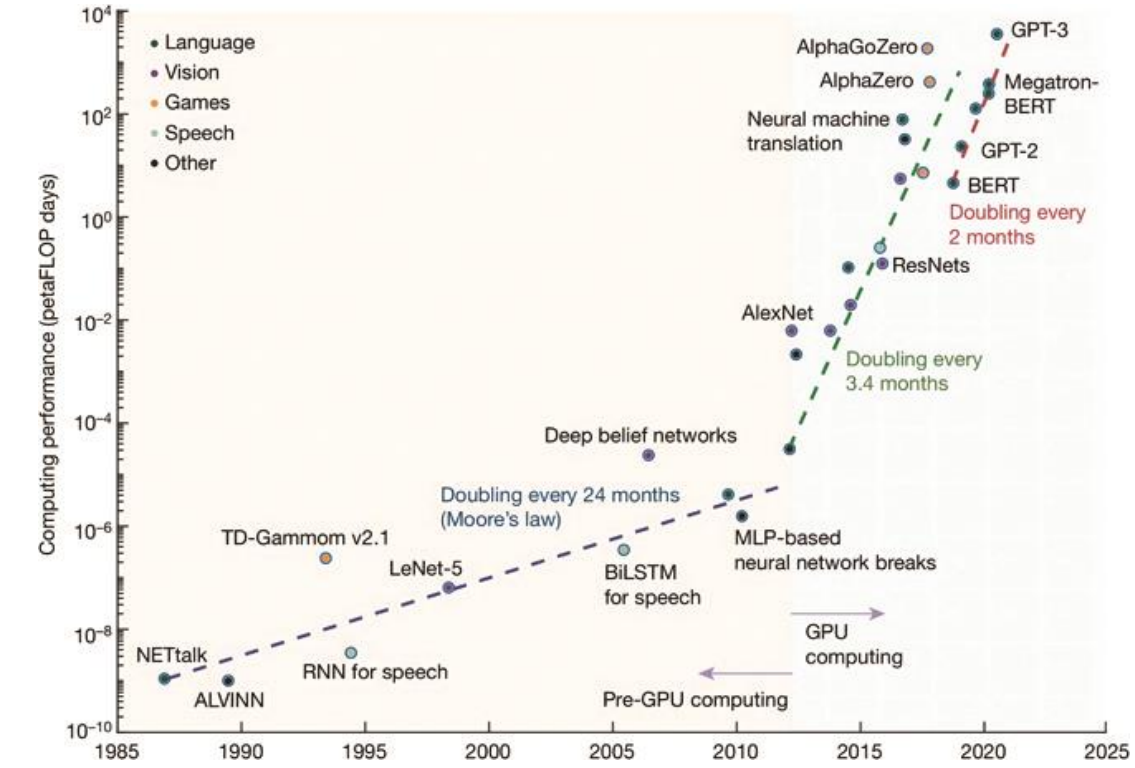

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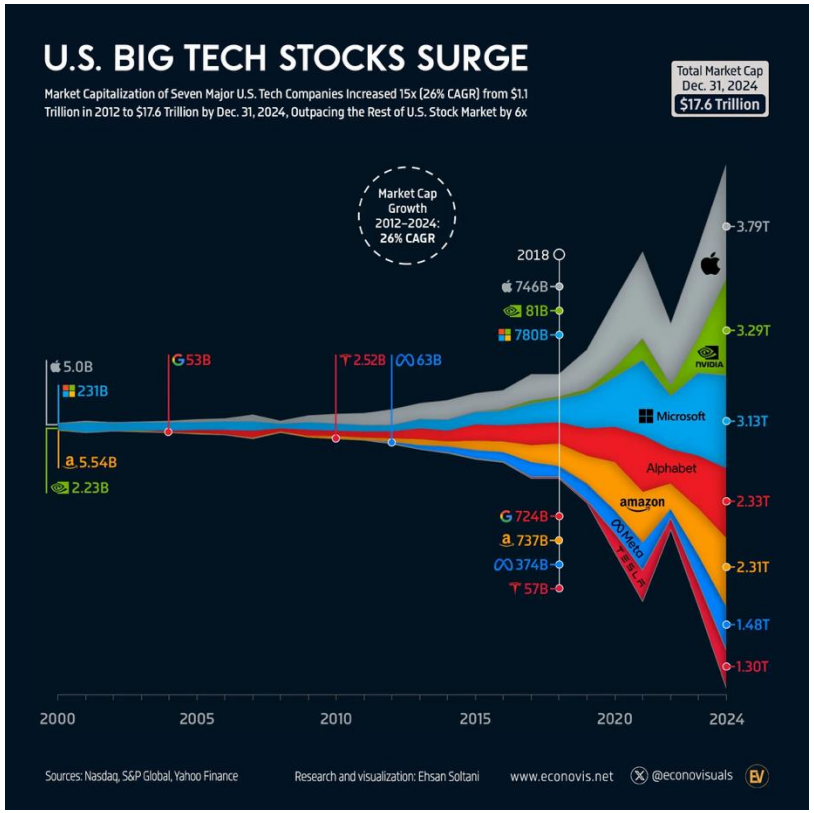


41% of companies worldwide plan to reduce workforces by 2030 due to AI

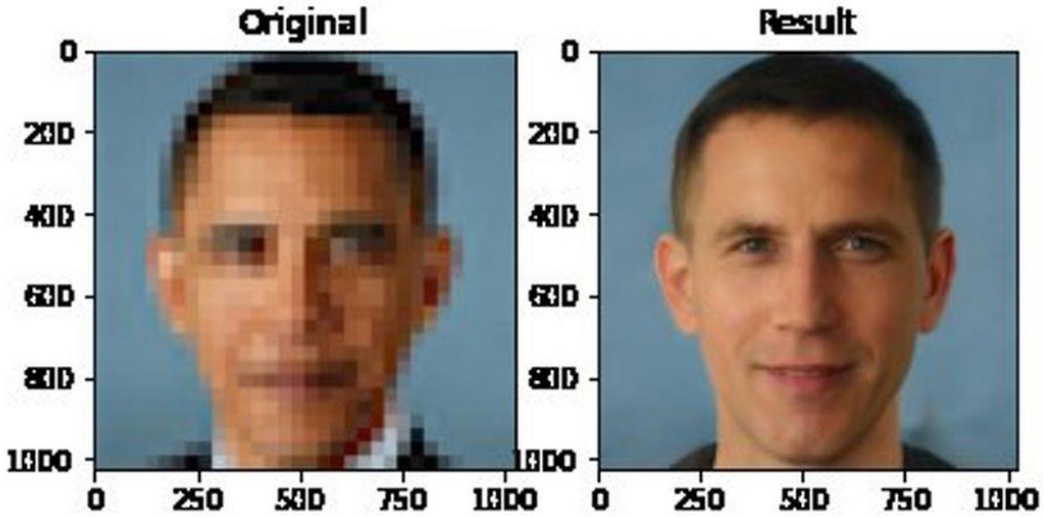
By Olesya Dmitracova, CNN

2 minute read · Published 7:57 AM EST, Wed January 8, 2025

The Latest Advances, Challenges, and Future, in Intelligent Computing, 2022

You may have heard of “Deep Learning” or “Artificial Intelligence (AI)”

Gender Classifier	Darker Male	Darker Female	Lighter Male	Lighter Female	Largest Gap
Microsoft	94.0%	79.2%	100%	98.3%	20.8%
FACE++	99.3%	65.5%	99.2%	94.0%	33.8%
IBM	88.0%	65.3%	99.7%	92.9%	34.4%



Grok’s antisemitic outbursts reflect a problem with AI chatbots

By Allison Morrow and Lisa Eadicicco, CNN

5 min read · Updated 10:59 AM EDT, Thu July 10, 2025

You may have heard of “Deep Learning” or “Artificial Intelligence (AI)”

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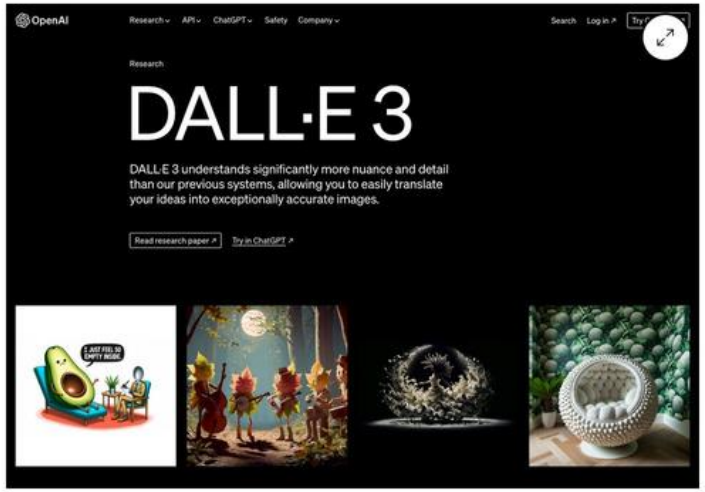
Technology
AI

Dall-E 3 Is So Good It’s Stoking an Artist Revolt Against AI Scraping

Artists are worried AI will take their jobs — so they’re getting creative.



The Dall-E 3 website.

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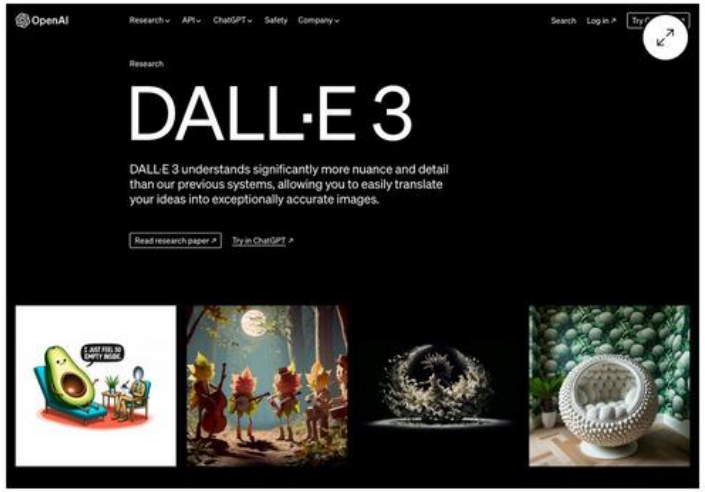

The Dall-E 3 website.

SANDER VAN DER LINDEN IDEAS JAN 22, 2024 7:00 AM

AI-Generated Fake News Is Coming to an Election Near You

Targeted, AI-generated political misinformation is already out there—and humans are falling for it.

PHOTO-ILLUSTRATION: LAUREN JOSEPH; GETTY IMAGES

Our goal is to answers some important questions

ChatGPT prompt “a cartoon of a mole with a question mark”

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- What is Deep Learning?

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- **Why Now**?

ChatGPT prompt “a cartoon of a mole with a question mark”

Today’s Goals:

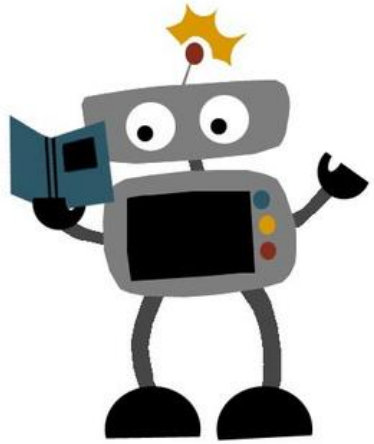
What is Deep Learning?

(1) What is Machine Learning?

(2) How Does Deep Learning fit in?

(3) What is NOT Deep Learning?

What is Machine Learning?



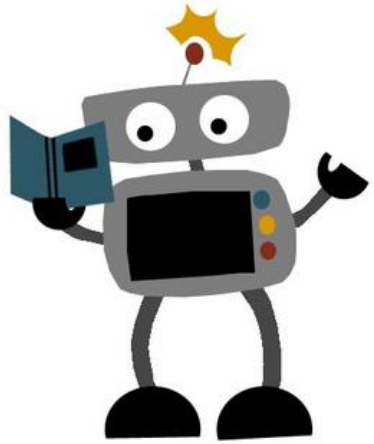
Input: X

Function: f

Output: Y

”Cooking?”

What is Machine Learning?



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f(X) ⟶ Y

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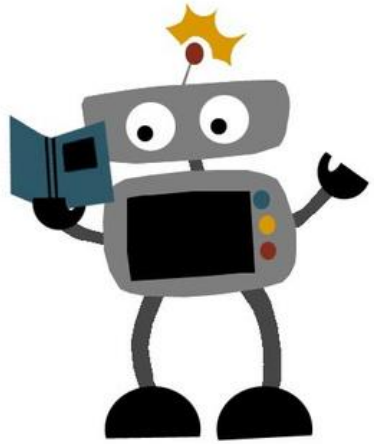

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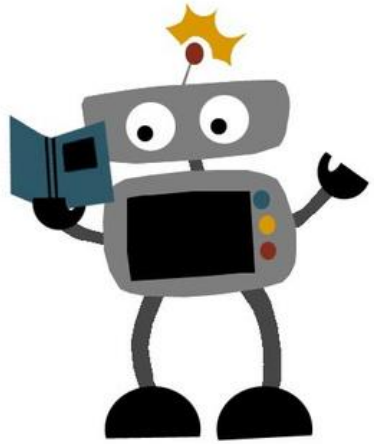


Function: f

”Cooking?”

Input: X

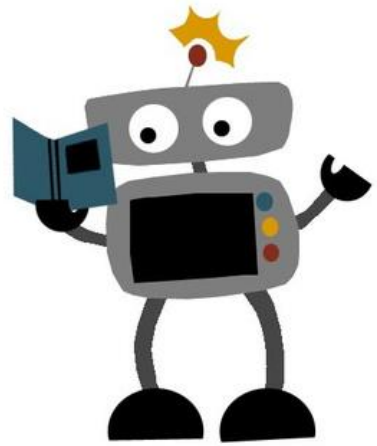
Learned function: f

Output: Y

”Cooking?”

f(X) ⟶ Y

What is Machine Learning?



Supervised Learning

Function: f

”Cooking?”

Input: X

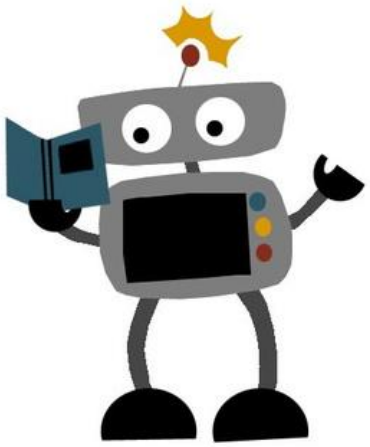
Learned function: f

Output: Y

”Cooking?”

f(X) ⟶ Y

What is Machine Learning?



Input: X

I do not want sour cream in my burrito

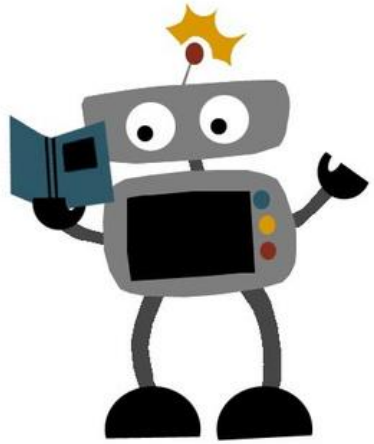
Learned function: f

Output: Y

No quiero crema agrea en mi burrito

$f(X) \longrightarrow Y$

What is Deep Learning?



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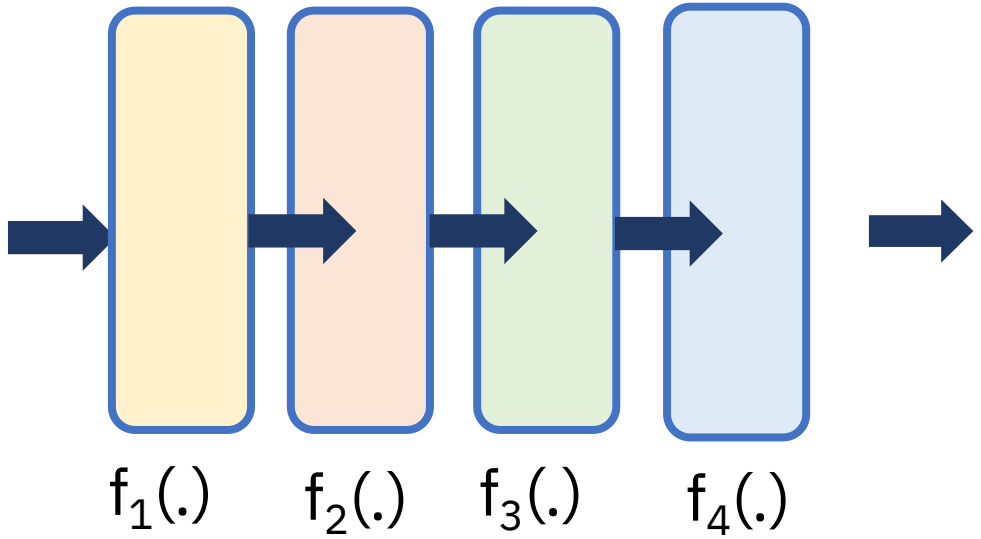

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”Cooking?”

$$f_4\,(f_3\,(f_2\,(f_1\,(X)))) \longrightarrow Y$$

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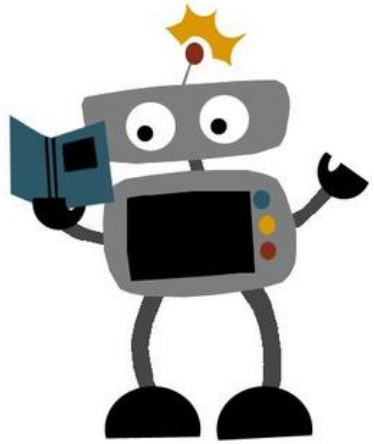

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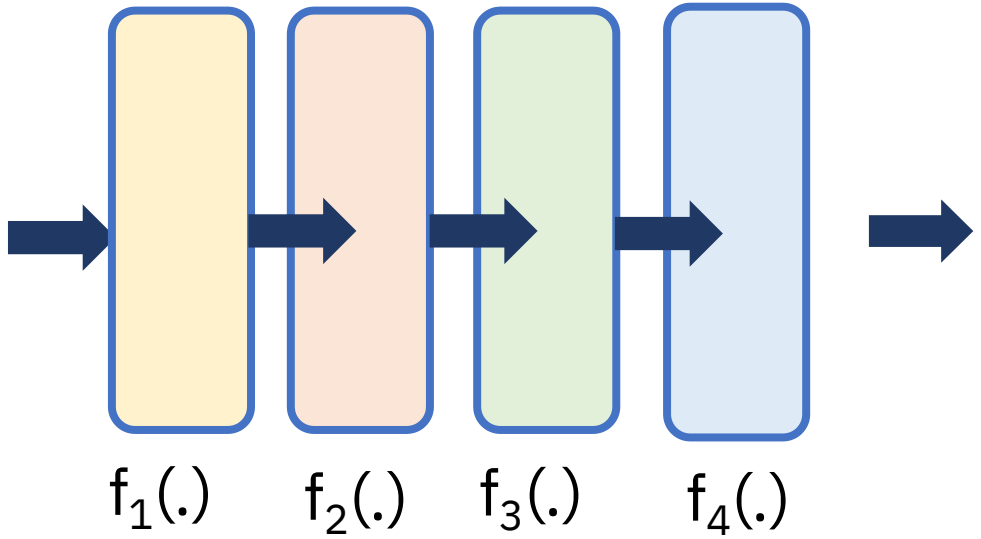

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”Cooking?”

Neural Network

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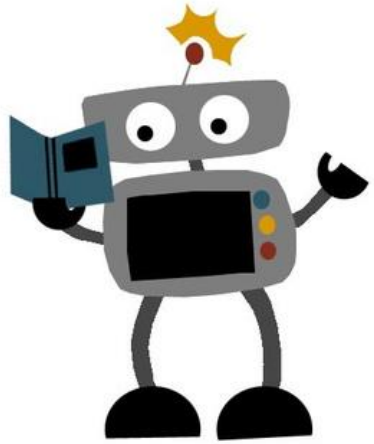

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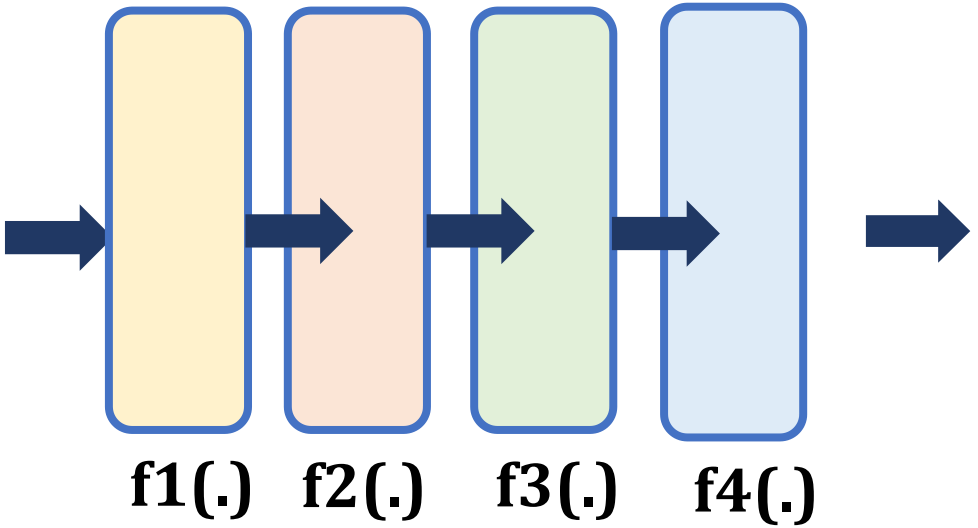

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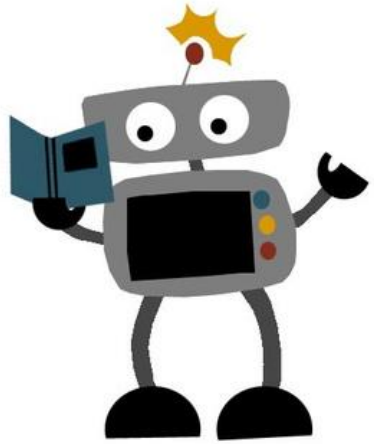

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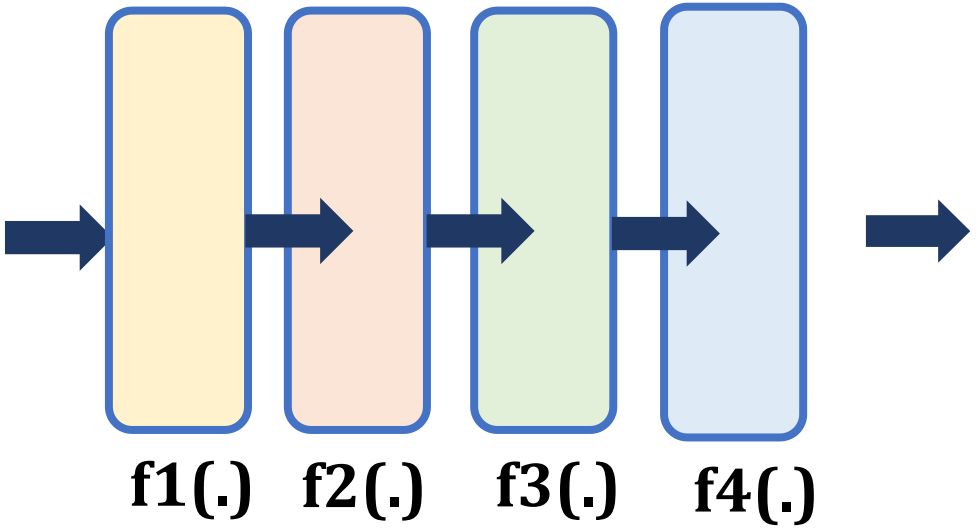

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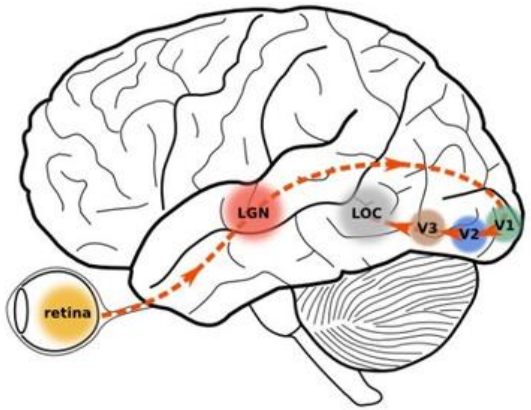

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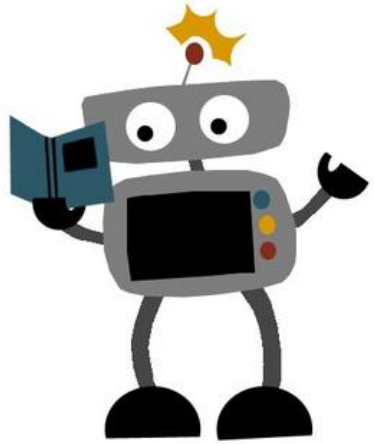

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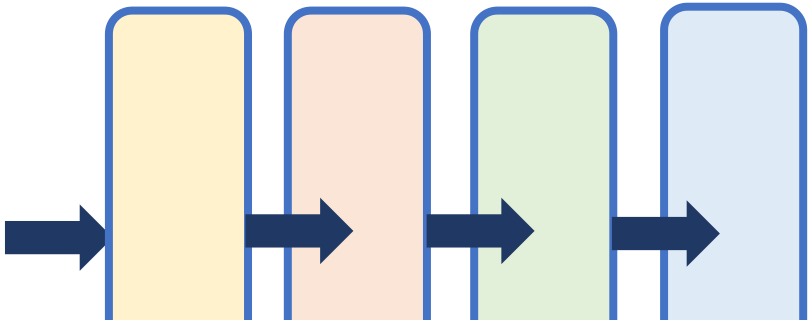

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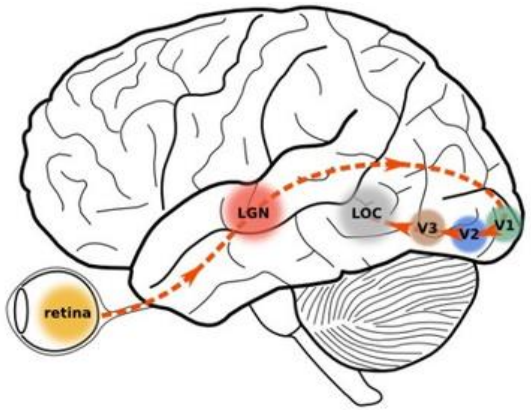
TURN ANY PHOTO INTO AN ARTWORK – FOR FREE!

We use an algorithm inspired by the human brain. It uses the stylistic elements of one image to draw the content of another. Get your own artwork in just three steps.

[https://deepart.io]



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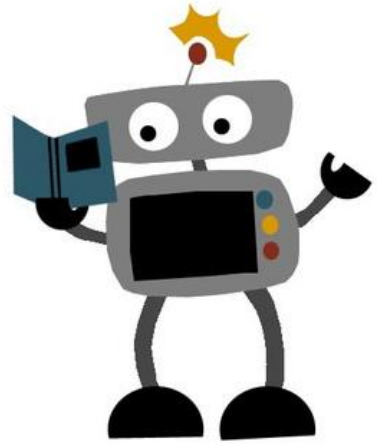

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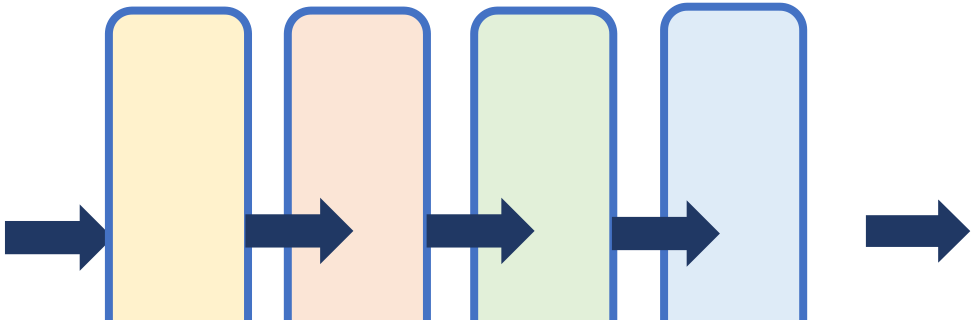

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[https://builtin.com/artificial-intelligence/deep-learning]

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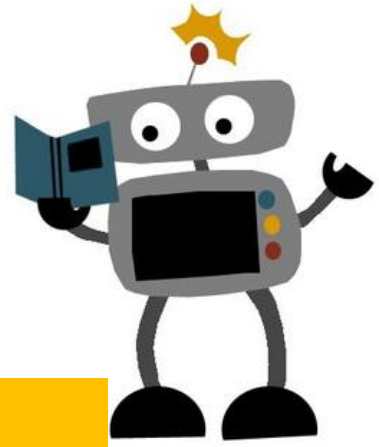

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Deep Learning DOES NOT mimic the brain!

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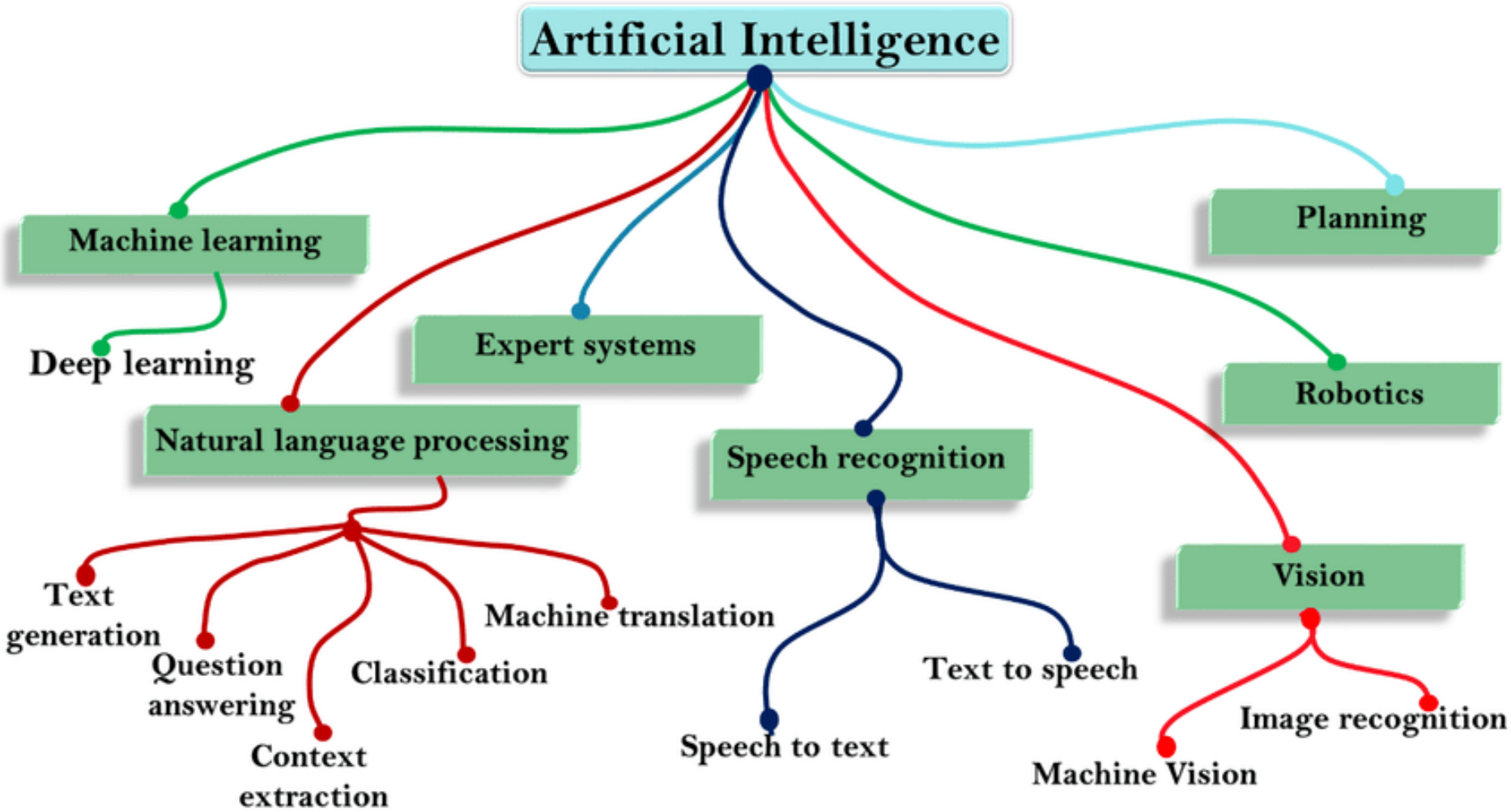

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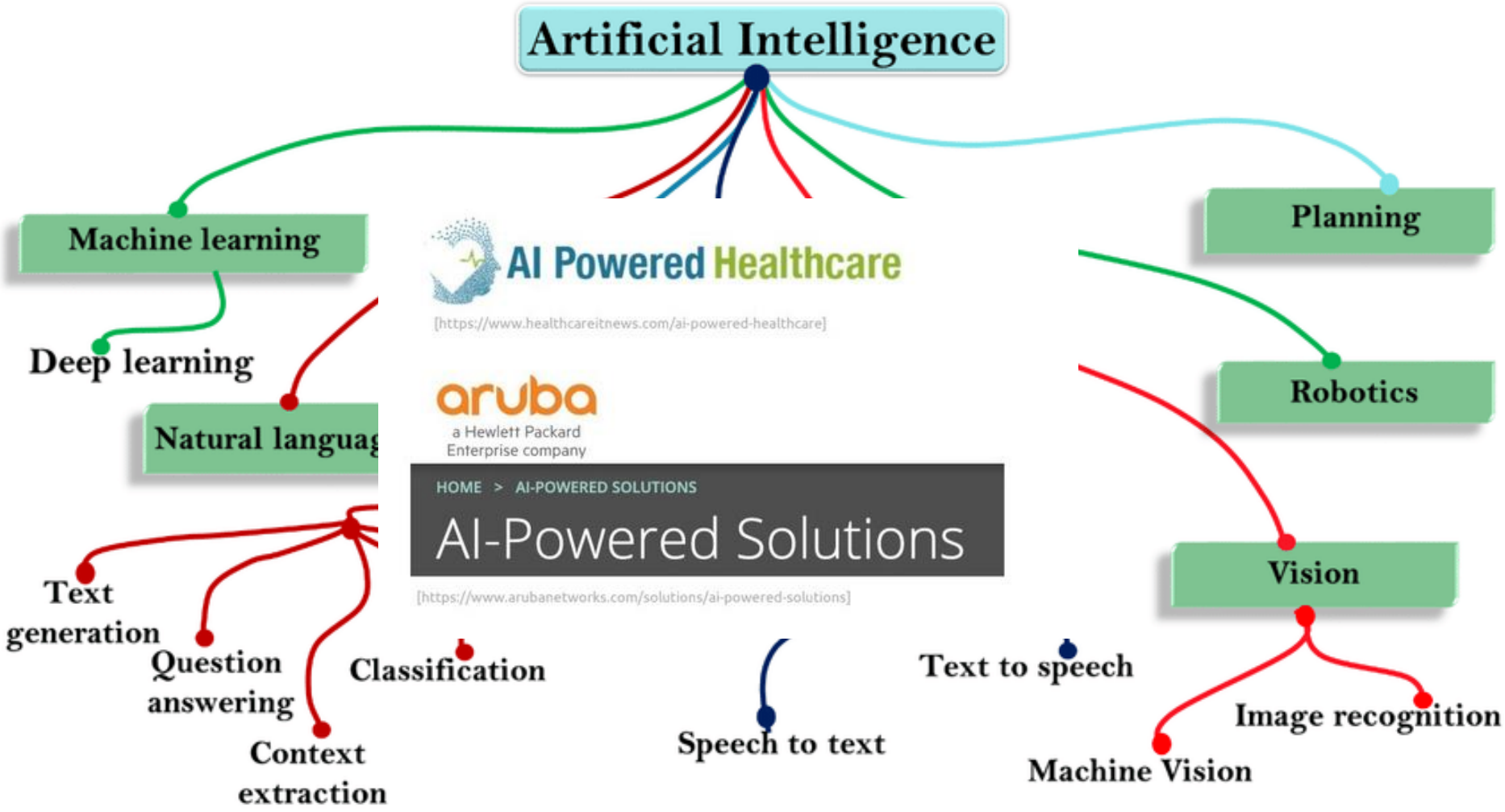
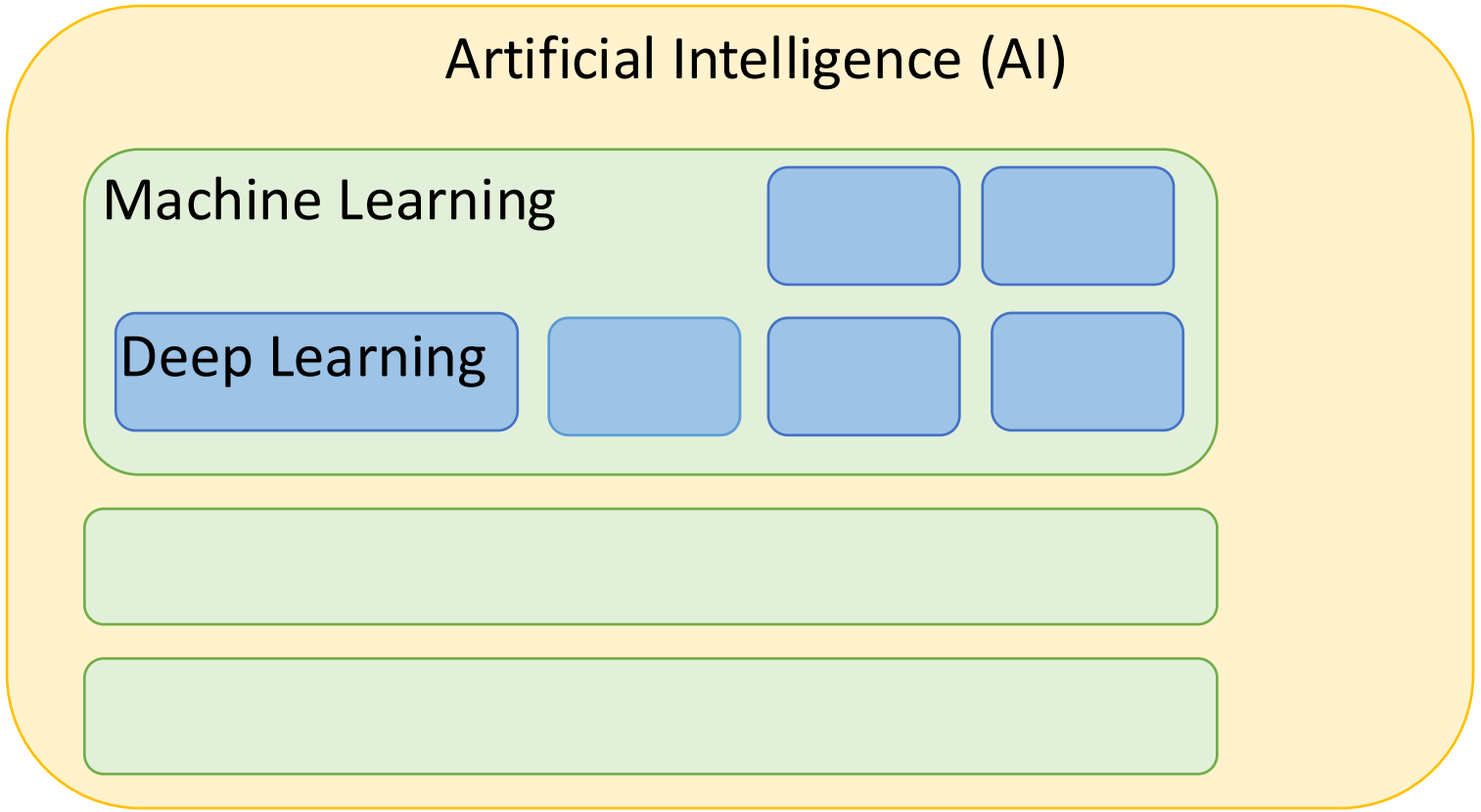
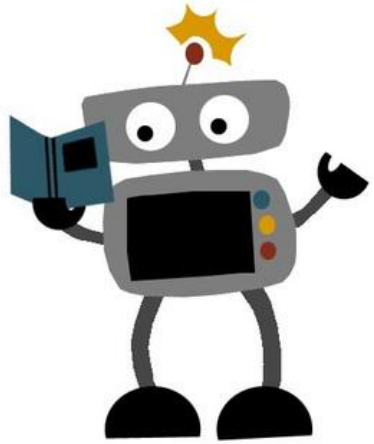


What is NOT Deep Learning?

Deep Learning is NOT equivalent to AI

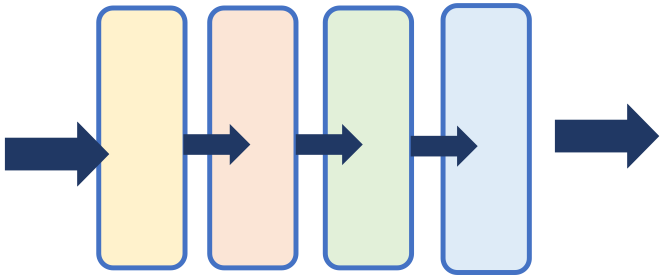


Recap



Input: X

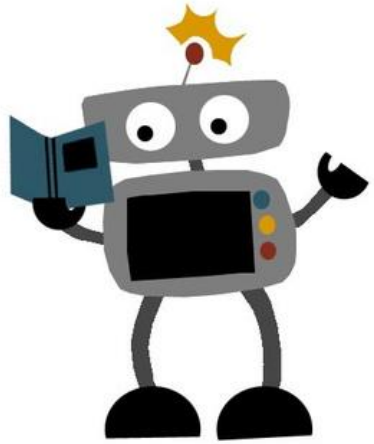
Machine Learning



Output: Y

”Cooking?”

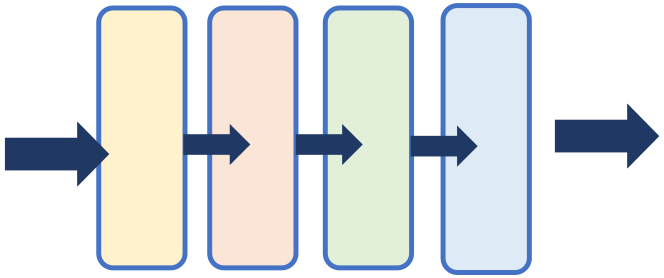
Recap



Input: X

Machine Learning

$f(X) \rightarrow Y$



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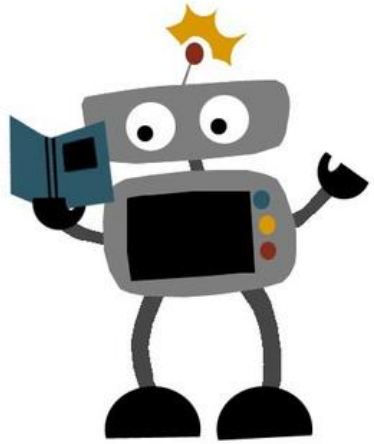

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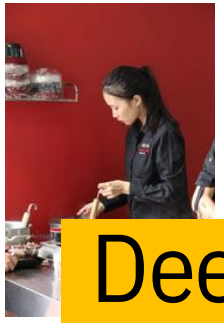

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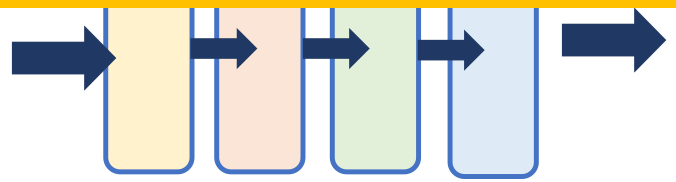
Deep Learning is NOT equivalent to AI



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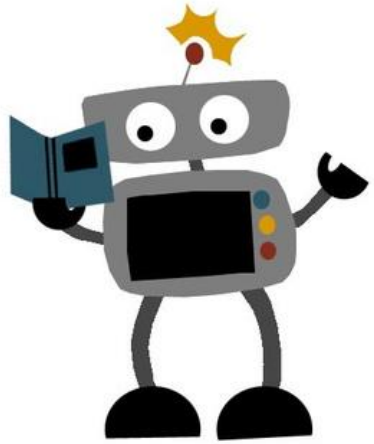

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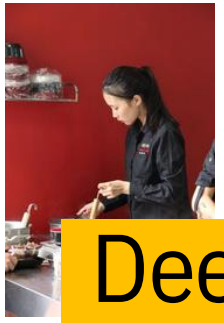

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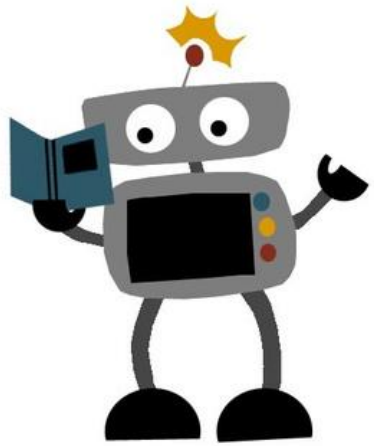
Deep Learning is NOT equivalent to AI

Deep Learning DOES NOT mimic the brain!

Recap



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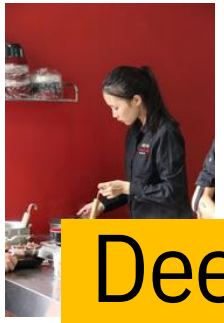

Machine Learning

$f(X) \rightarrow Y$

Output: Y

”Cooking?”

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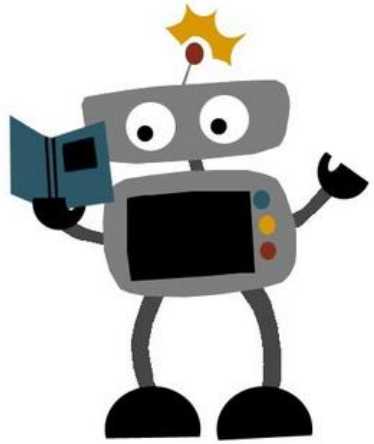
Deep Learning

$f_4(f_3(f_2(f_1(X)))) \rightarrow Y$

How do we represent Input/Output?



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”Cooking?”

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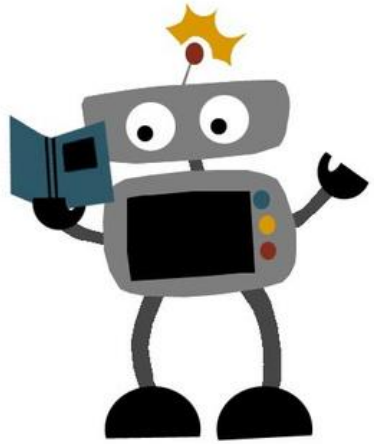

Computers work with numbers!

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Function: f

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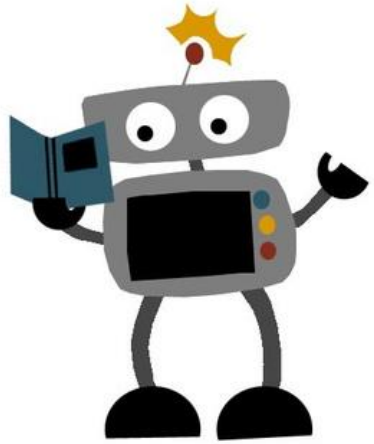
f(X) ⟶ Y

How do we represent Input/Output?



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Function: f

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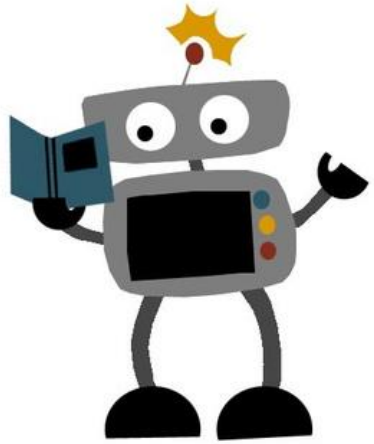
”Cooking?”

How can we represent output labels as numbers?

f(X) ⟶ Y

How do we represent Input/Output?



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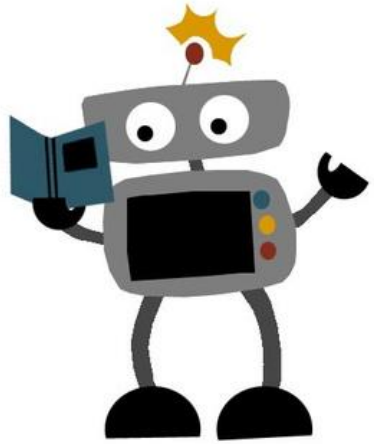

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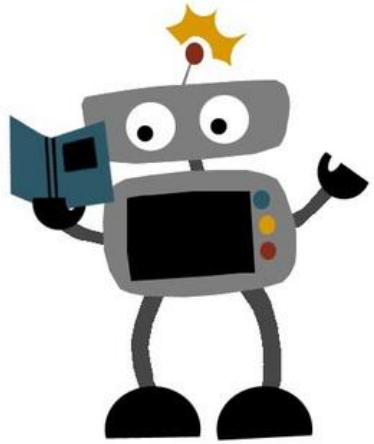

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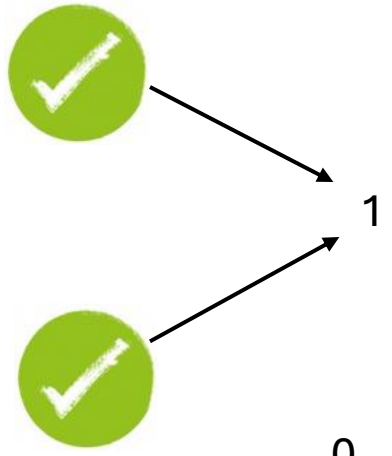
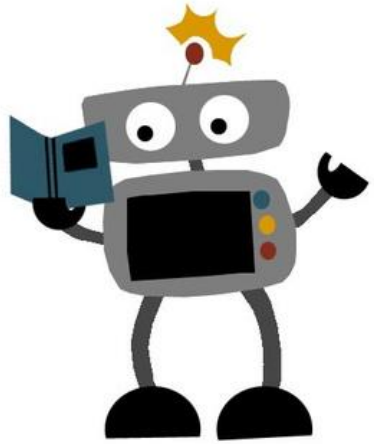


y ∈ {0,1}

How do we represent Input/Output?



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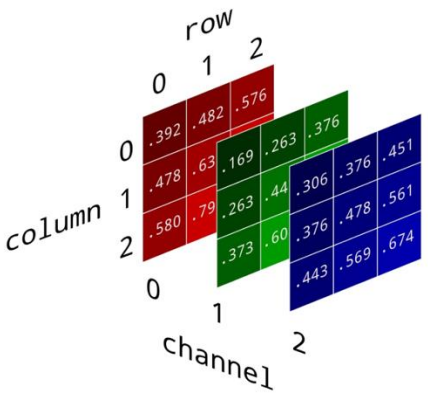
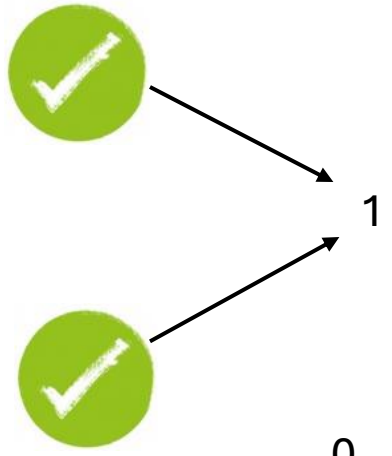


Function: f

Output: Y

"Cooking?"

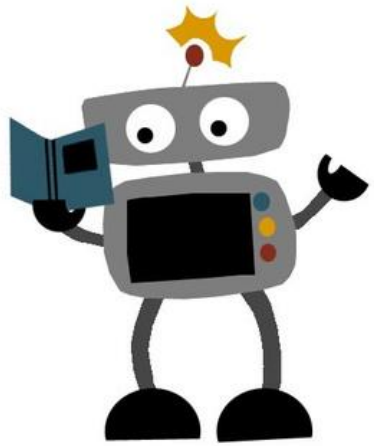


$X \in \mathbb{R}^{HxWx3}$

f(X) ⟶ Y

y ∈ {0,1}

Classification



When y is discrete, the task is **classification**

Input: X

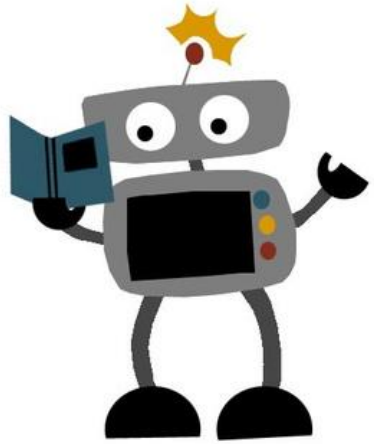
Function: f

f(X) ⟶ Y

Output: Y

”Cooking?”

Classification



When y is discrete, the task is **classification**

When $y \in \{0, 1\}$ the task is **Binary Classification**

Input: X

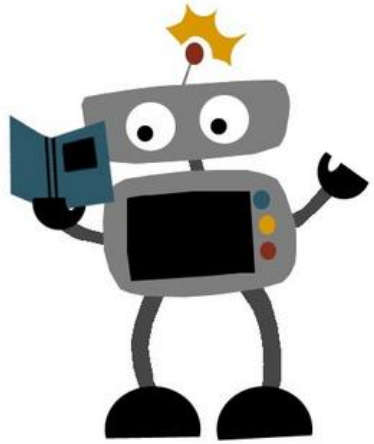
Function: f

f(X) ⟶ Y

Output: Y

"Cooking?"

Classification



When y is discrete, the task is **classification**

When $y \in \{0, 1\}$ the task is **Binary Classification**

What's an example of **multi-class Classification?**

Input: X

Function: f

f(X) ⟶ Y

Output: Y

"Cooking?"

Questions?

Ice Breaker!

- Turn to the person sitting next to you and introduce yourself!
- What do you hope to learn/be able to do by the end of this course?

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https://forms.gle/oCY6wZfd7fdEA6HEA

Course Logistics

The Canvas Website

CSCI1470 Fall25 S01 Deep Learning

Jump to Today

Welcome to Deep Learning! Over the past few years, Deep Learning has become a popular area, with deep neural network methods obtaining state-of-the-art results on applications in computer vision (Self-Driving Cars), natural language processing (Google Translate), and reinforcement learning (AlphaGo). These technologies are having transformative effects on our society, including some undesirable ones (e.g. deep fakes).

This course is there to give students a practical understanding of how Deep Learning works, how to implement neural networks, and how to apply them ethically. We introduce students to the core concepts of deep neural networks and survey the techniques used to model complex processes within the contexts of computer vision and natural language processing.

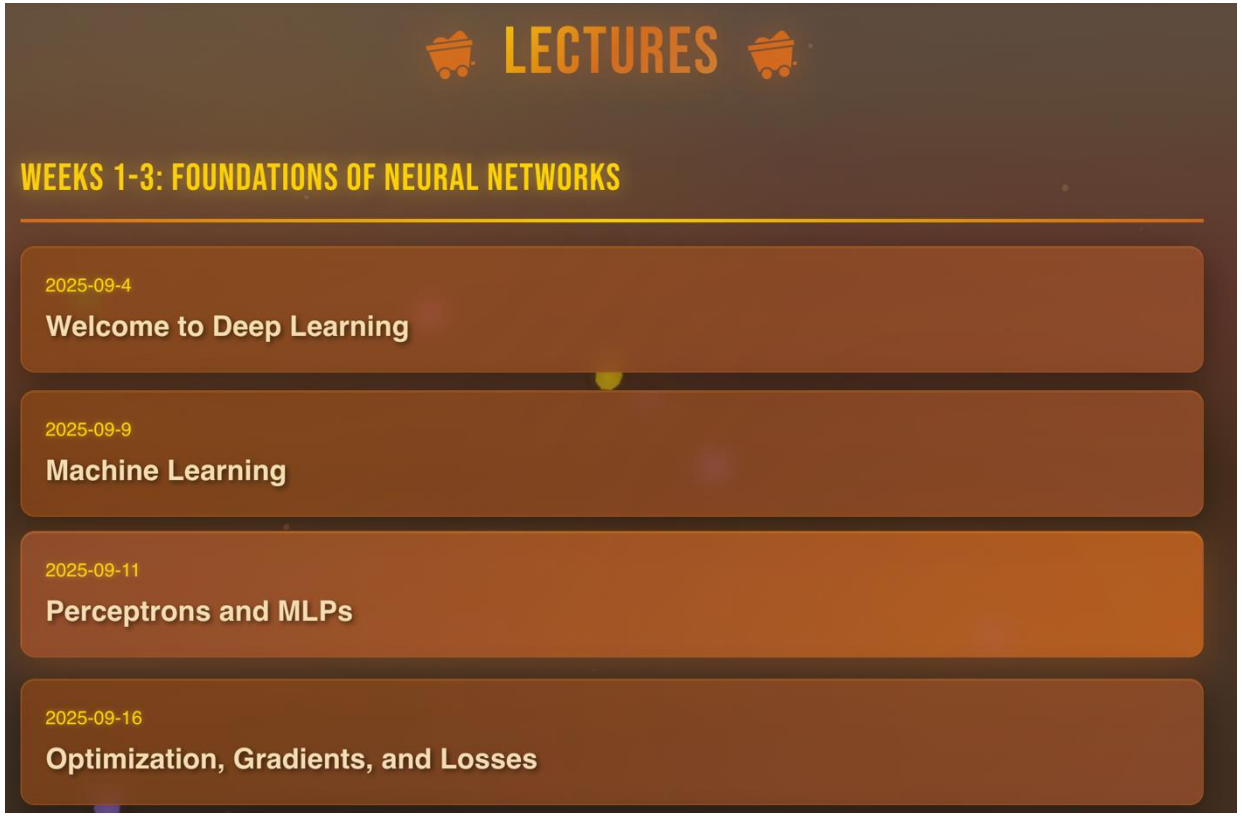
Throughout the course, we emphasize and require students to think critically about potential ethical pitfalls that can result from mis-application of these powerful models. The course is taught using the Tensorflow deep learning framework.

Course Website: https://dl-website-f25.vercel.app/

Your access to:

- Ed Discussion
- GradeScope
- Weekly quizzes

The Course Website



- Your one-stop-shop for:
  - Syllabus Lecture, lab, & assignment
  - schedules Links to important forms,
  - etc. ...

Brown Deep Learning Day!

- Course final project

- In-person mini conference!

- Poster sessions and presentations
  - Grouped by theme: e.g. vision, language, robotics, …

Details forthcoming!

Deep Learning Day (Spring 2022)

Gen-AI Policy (LLMs)

Help with assignments:

- Submitting AI generated code or problem set answers without attaching a transcript is forbidden unless specifically stated otherwise and is an academic code violation.
- We will provide opportunities for working with AI tools, notably the final project and a few homeworks will allow AI use.

Help with content:

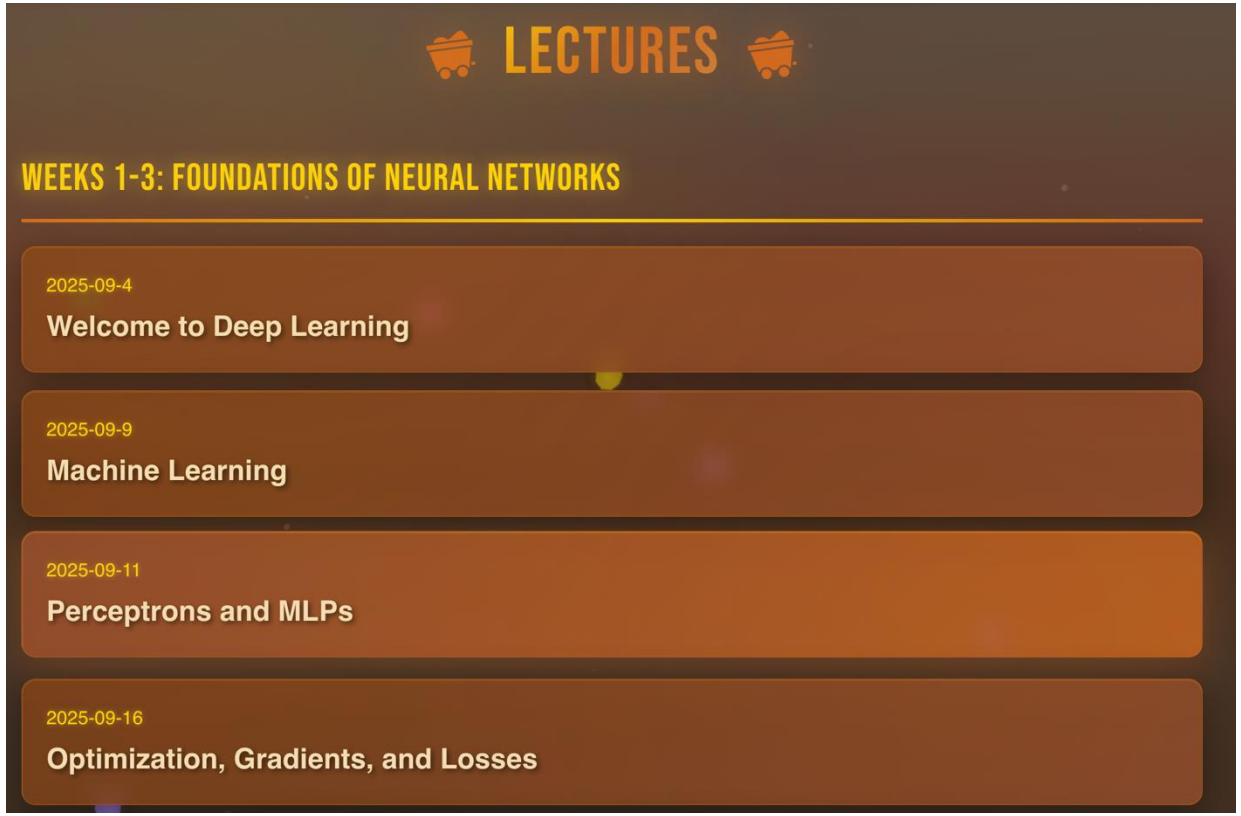
Use LLMs to help you learn, not to give you the answers.

Have LLMs quiz you on topics, have them point you to helpful resources, or brainstorm ideas together.

Lectures and class participation

- In-person Lectures
  - Lecture recordings available
  - Recordings posted to Canvas (Media Library)

- Weekly quiz on Canvas
  - Released on Tuesdays in class (starts next week!)
  - Due on Tuesday at midnight
  - Minimum time/effort if you attend class or watch lectures regularly
  - No deadline extensions!



Homework

- Homework 1 (will be released today!)
  - Review of relevant math and probability concepts
  - Setting up programming environment
  - Graded for completion only (**deadline Sept 18th**)

Homework

- Homework 2: Introduction to Numpy and Tensorflow
- Homework 3: Beras: Neural networks from scratch
- Homework 4: Convolutional Neural Networks
- Homework 5: Language Modeling (RNNs and LLMs)
- Homework 6: Image Captioning
- Homework 7: Generative Modeling
- Homework 8: Deep Reinforcement Learning

Workshops and SRC Discussions

- SRC Discussion Sections focus on a variety of ethical issues in deep learning and how to overcome them.
- Workshops will important skills/applications of deep learning that we think are useful for working on your final project
  - How to read and implement an academic research paper
  - Other deep learning frameworks/tools
  - Applications (DL for biology, LLMs, theory, etc.)

- Each is an hour long with multiple time slots offered
- Required to attend 3 total, minimum one of each

Acknowledgements

Ritambhara Singh
(taught in Spring 2024)

Professor Chen Sun
(taught 2470 in Fall 2024)

Original course material developed by
Professor Daniel Ritchie and
previous FABULOUS TA staff

Questions?

Machine Learning

What does it mean to **learn**?

Machine Learning

Machine Learning

What does it mean to **learn**?

- The more information you have available, the better you should do.
- Learning often involves abstracting large amounts of data into smaller “models” of the world

Simpler example: Lemonade Stand

"Temperature"

100.1 °F

80.0 °F

30.3 °F

"Profit made on selling lemonade"

$200.0

$180.5

$115.1

Some Notation

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$\mathbb{R}$: The set of real numbers

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$v \in \mathbb{R}^d$: A **vector** in dimension d

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$\mathbb{X}$: A set of **input** data

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$\mathbb{Y}$: A set of target variables (outputs/labels) for supervised learning

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$x^{(k)}$: k'th example (input) from dataset

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$\mathbb{X}$: A set of **input** data

$\mathbb{Y}$: A set of target variables (outputs/labels) for supervised learning

$x^{(k)}$: k'th example (input) from dataset

$y^{(k)}$: k'th example (output) associated with $x^{(k)}$

Simpler example: How do we represent input/output?

Input: $\mathbb{X}$

"Temperature"

$\mathbb{X} \in \mathbb{R}$

$x^{(1)}$	100.1 °F
$x^{(2)}$	80.0 °F
$x^{(3)}$	30.3 °F

Function: f

Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$y^{(1)}$	$200.0
$y^{(2)}$	$180.5
$y^{(3)}$	$115.1

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

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Do you see a trend here?

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$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

Do you see a trend here?

What is different about the output here?

Simpler example: How do we represent input/output?

Input: $\mathbb{X}$

"Temperature"

Regression

Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$x^{(1)}$ 100.1 °F

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$x^{(3)}$ 30.3 °F

$\mathbb{X} \in \mathbb{R}$

Function: f

f(X)→Y

$y^{(1)}$ $200.0

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$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

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Learning function f

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(Image only for explaining concept, not drawn accurately)

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Function: f

Step 1: Model Hypothesis: What function do we think best fits the data

Target: $\mathbb{Y}$

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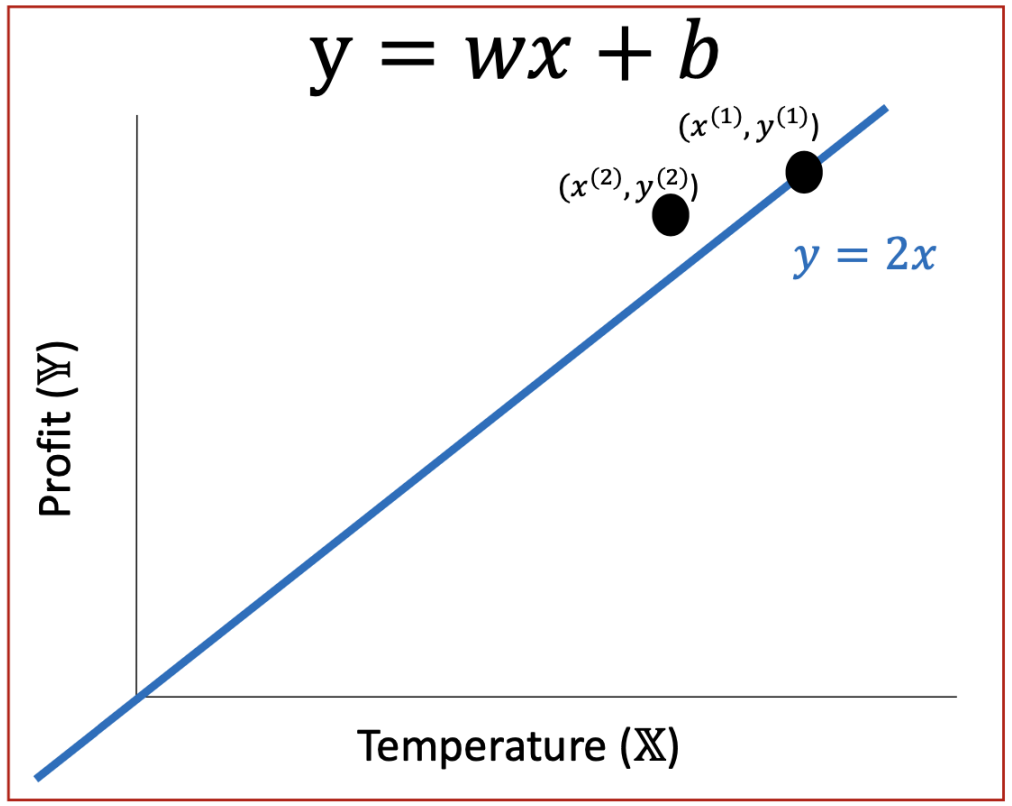
Linear function

$$y = wx + b$$



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$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

(Image only for explaining concept, not drawn accurately)

Learning function f

Have you seen this equation before?

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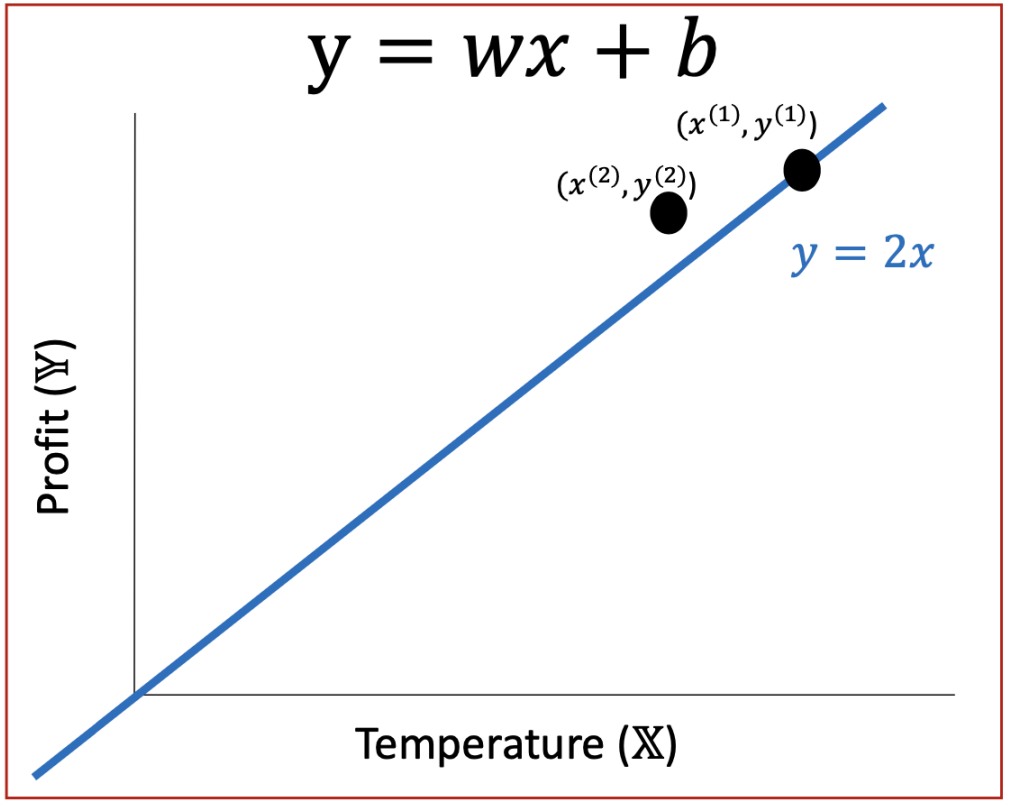

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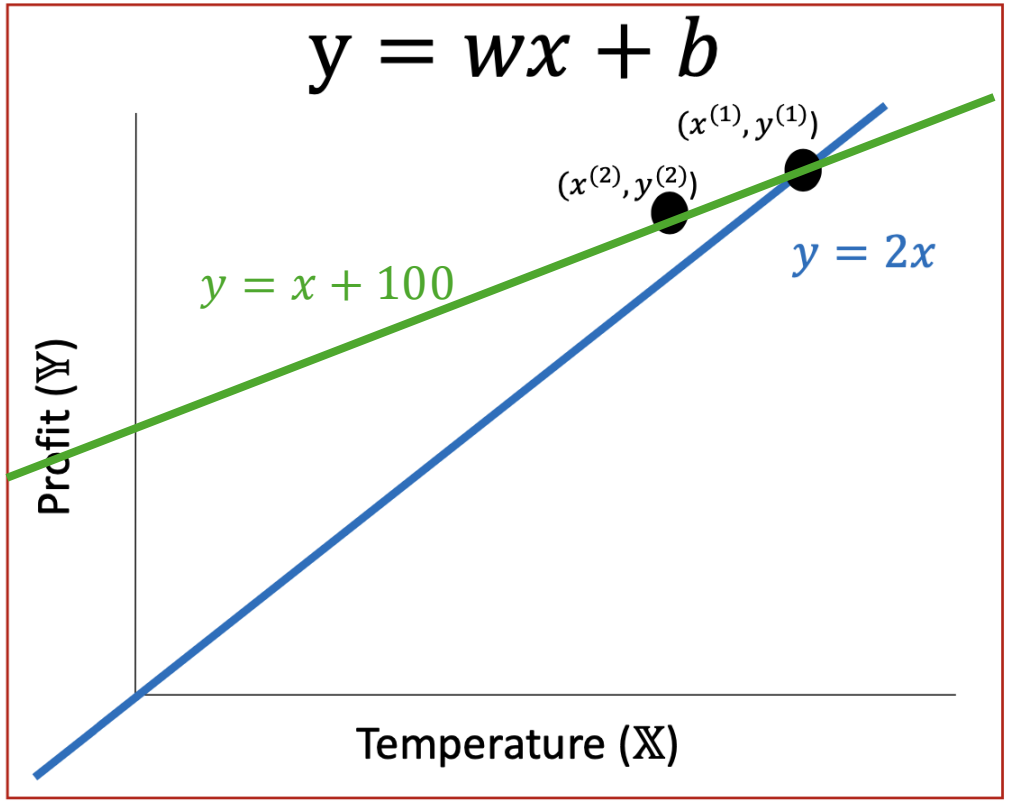

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$y^{(2)} = 180.5$

$y^{(3)} = 115.1$

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

(Image only for explaining concept, not drawn accurately)

Learning function f

Input: $\mathbb{X}$

"Temperature"

$x^{(1)} = 100.1$

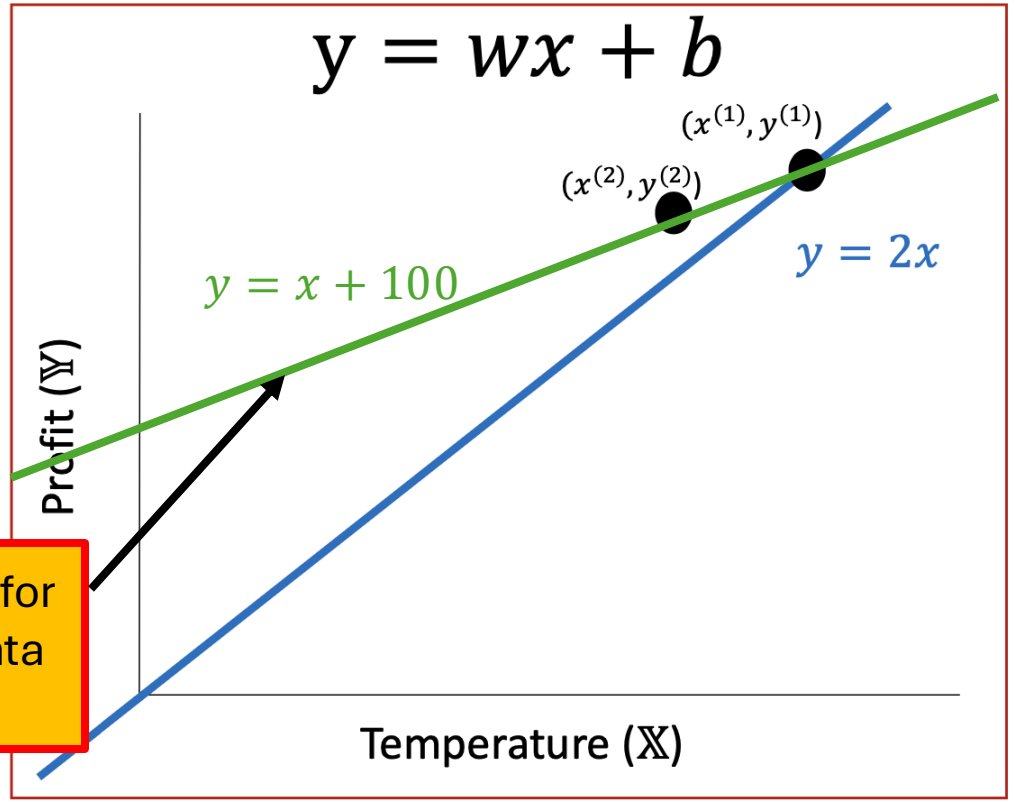
$x^{(2)} = 80.0$

$x^{(3)} = 20.2$

$\mathbb{X} \in \mathbb{R}$

Linear function

$$y = wx + b$$



Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$y^{(1)} = 200.0$

$y^{(2)} = 180.5$

$y^{(3)} = 115.1$

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

Bias term is necessary for best fit line to fit the data well

(Image only for explaining concept, not drawn accurately)

Learning function f

Input: $\mathbb{X}$

"Temperature"

$\mathbb{X} \in \mathbb{R}$

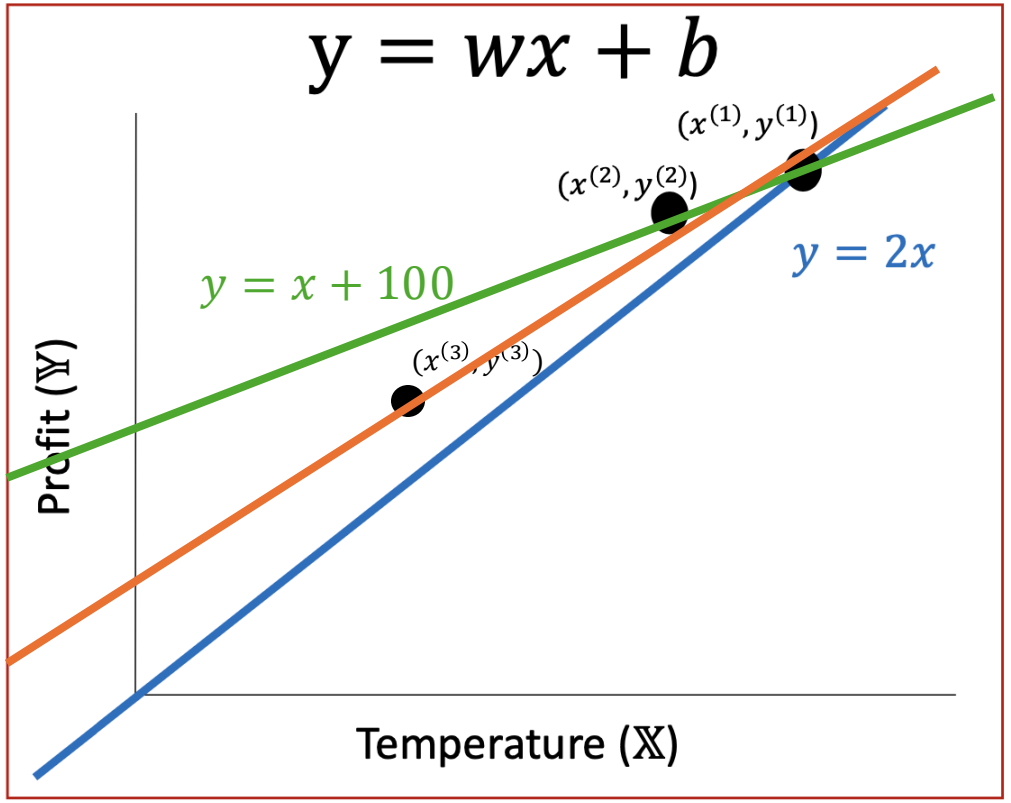
$x^{(1)} = 100.1$

$x^{(2)} = 80.0$

$x^{(3)} = 30.3$

Linear function

$$y = wx + b$$



Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$y^{(1)} = 200.0$

$y^{(2)} = 180.5$

$y^{(3)} = 115.1$

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

(Image only for explaining concept, not drawn accurately)

Learning function f

Input: $\mathbb{X}$

"Temperature"

$\mathbb{X} \in \mathbb{R}$

$x^{(1)} = 100.1$

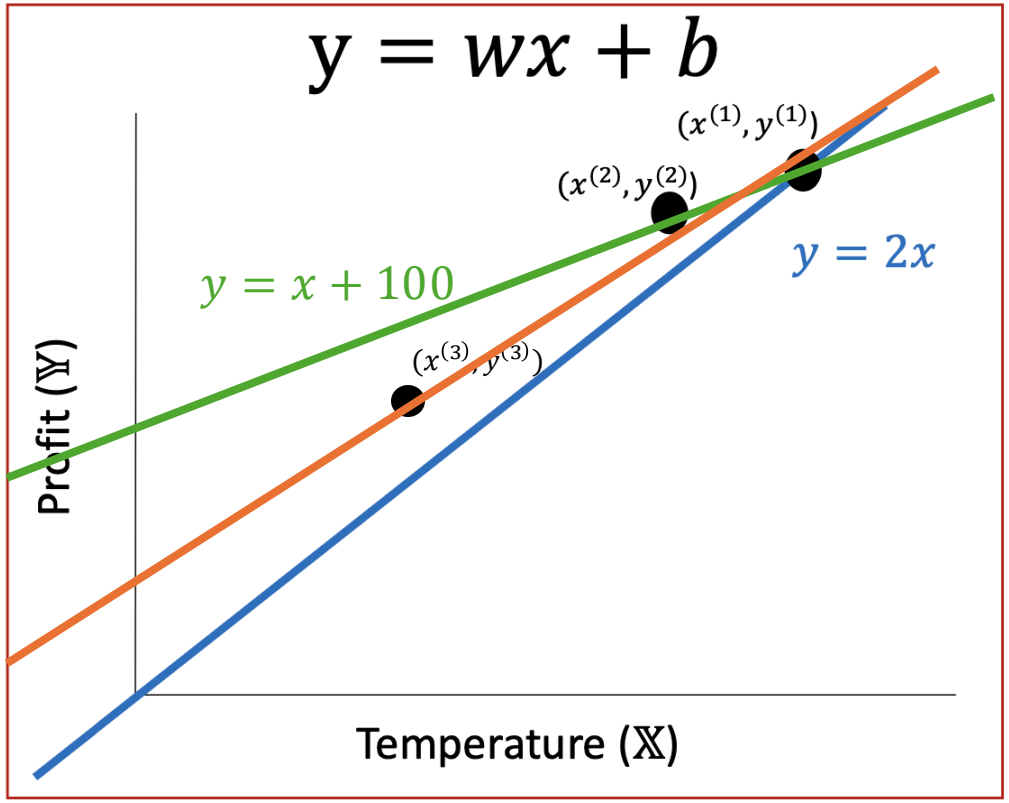
$x^{(2)} = 80.0$

$x^{(3)} = 30.3$

Hard to find these functions by hand...

Linear function

$$y = wx + b$$



Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$y^{(1)} = 200.0$

$y^{(2)} = 180.5$

$y^{(3)} = 115.1$

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

(Image only for explaining concept, not drawn accurately)

Learning function f

Input: $\mathbb{X}$

"Temperature"

$x^{(1)} = 100.1$

$x^{(2)} = 80.0$

$x^{(3)} = 30.3$

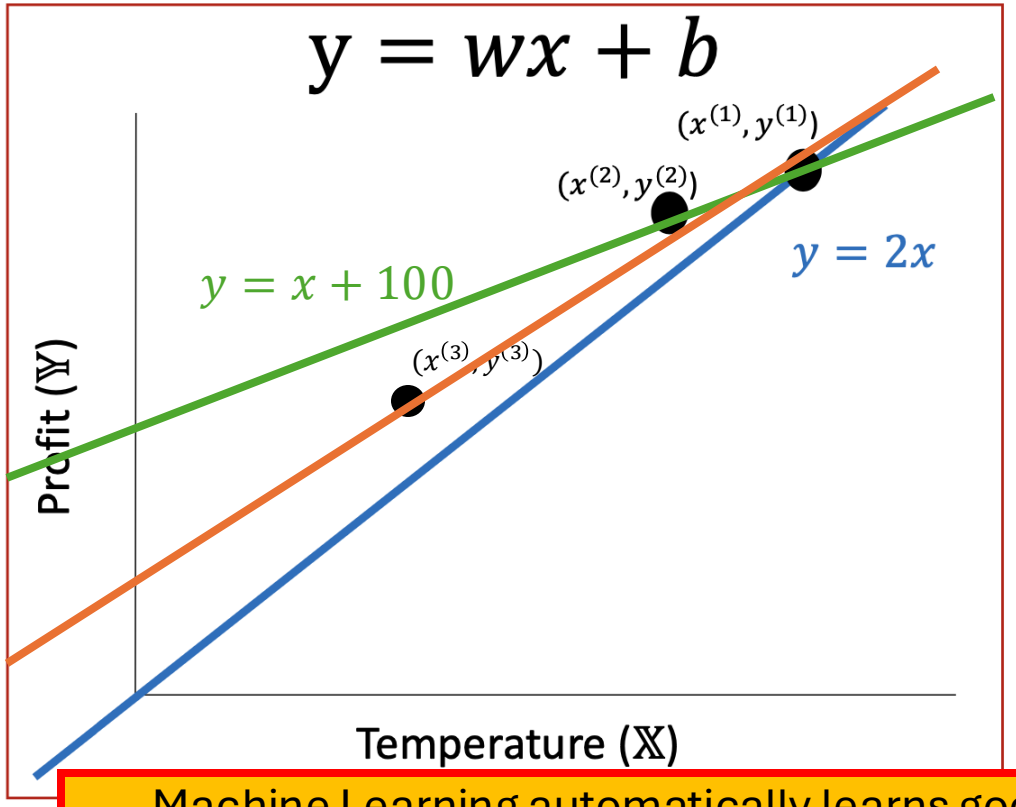
$\mathbb{X} \in \mathbb{R}$

Hard to find these functions by hand...

(Image only for explaining concept, not drawn accurately)

Linear function

$y = wx + b$



Target: $\mathbb{Y}$

"Profit made on selling lemonade"

$y^{(1)} = 200.0$

$y^{(2)} = 180.5$

$y^{(3)} = 115.1$

$\mathbb{Y} \in \mathbb{R}$

(Numerical output)

Machine Learning automatically learns good **approximations** of f from **data** (or at least tries to)

Recap

ML Goal: Learn to approximate f, where $f(X) \longrightarrow Y$

Deep Learning: $f_4(f_3(f_2(f_1(X)))) \longrightarrow Y$

Discrete Outputs $\longrightarrow$ Classification

Continuous Outputs $\longrightarrow$ Regression

Remaining Questions:

How do we determine if one approximation of f is better than another?